

Assembly

General Information Cleanliness

You've invested considerable time in meticulously cleaning and reconditioning the engine components. Assembling the engine takes the same kind of care. If you become impatient as assembly progresses, stop! If you rush the assembly, you'll probably make a mistake; and if your mistake is significant enough, you'll have to pull the engine out to repair it. If you don't think you have time to do the job correctly *now*, do you really think you'll have time to redo it *later*?

Nor can you allow the parts to become dirty. Most engine components have carefully machined surfaces that operate within tolerances not much larger than the thickness of a human hair. If dirt is allowed to get between these components, for whatever reason, they will die a premature death,

so they must be properly lubricated, handled, and stored.

Lay cleaned parts on newspaper. Any particles that the parts do pick up from the paper are easily tolerated inside the engine.

Lubricants

Basically speaking, three different types of lubricants are used during the assembly process: engine oil, assembly lube, and moly-bdenum disulphide (moly)-lube. Each of these lubricants has certain traits that makes it right for specific uses.

If assembly lube is called for, don't use engine oil because most commercial assembly lubes, including GM's Engine Oil Supplement (EOS), have high concentrations of zinc dithiophosphate (ZDP). This additive provides protection for parts working under extreme pressure, such as bearings, camshaft lobes, and lifter

feet. If engine oil is substituted, it will be pushed out from between these surfaces, allowing metal-to-metal contact.

Assembly lube is also good for engines that will be stored for a long period of time because it is quite thick and tenaciously clings to metal. This helps prevent a dry start when the time comes to start the engine.

Assembly lubes usually come with a complete rebuilding kit, but if yours lacks it you can purchase it at most auto parts stores or speed shops. Buy only high-quality, brand-name products—and don't forget about General Motor's EOS (part #1052367). EOS is available in the parts department at practically any GM dealership and is a good choice for an assembly lube. Buy at least one quart so you can add it to the crankcase in place of one quart of engine oil. This will significantly add to the protection of the internal engine components during break-in.

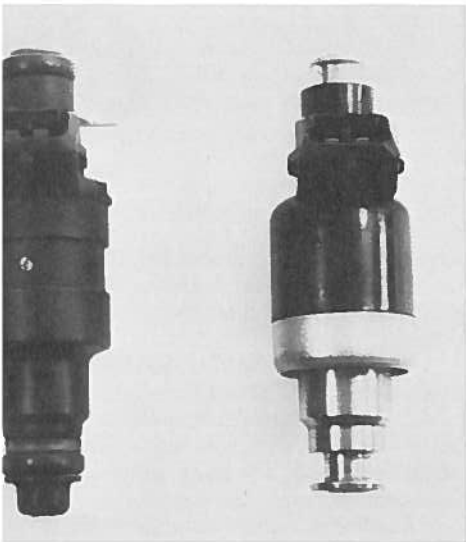
Moly-lubes are another type of extreme pressure lubricant, but they offer even more protection against metal-to-metal contact than assembly lubes. Moly-lube is strongly recommended for areas of extreme pressure, such as cam lobes and lifter feet. The disadvantage of moly-lube is that it can plug an oil filter within 20–30min after the engine has started. This is one of the reasons why the oil filter should be changed after the first 30min of engine operation. Moly-lube is available at most auto parts stores and speed shops.

Whatever you do, don't use lithium grease (also known as white grease) on camshaft bearings or any other engine component. Lithium grease tends to pack into the lubrication holes of the bearing during assembly. If the grease blocks the lube holes, it won't be forced out until the engine cranks upwards of fifty times or more. In the meantime, the bearings are wearing without the benefit of oil. Definitely a bad thing. Especially in light of the fact that the first time an engine is started after being rebuilt is the most important time in

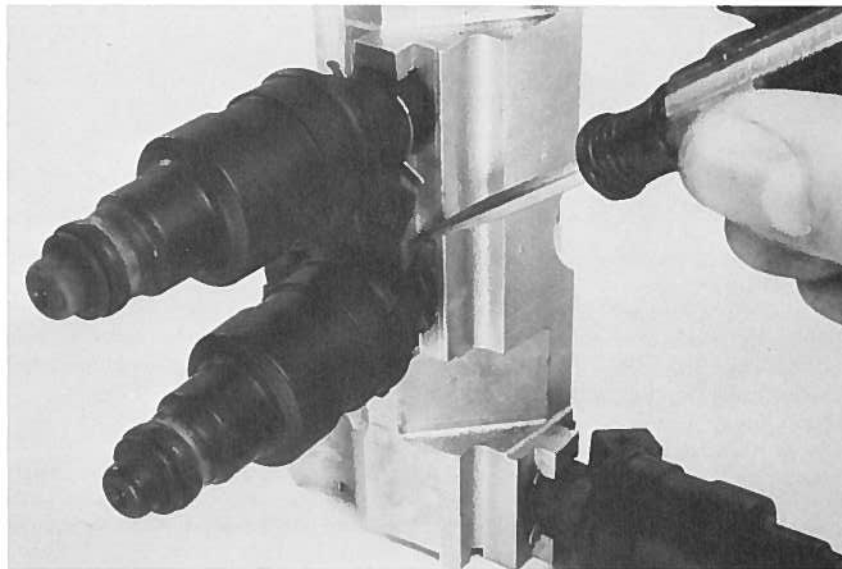


Using the right type of lubricant is critical during the assembly process. A couple quarts of GM Engine Oil Supplement (EOS) is great to have on hand and can be purchased at any GM deal-

ership. Assembly lubes and moly-lube can be purchased at auto parts stores and speed shops. Buy only name-brand products and stay away from products with unbelievable claims.



The pintle-style injector on the left was used on early engines. Self-cleaning Multec injectors (shown on the right) are used on later engines.



A metal ring locks each injector into the fuel rail. Unlock the injector by rotating the ring with a small screwdriver until its

open end faces the rib on the fuel rail. Then pull the injector out.

with engine oil and then pushing the injectors into the rail, with their electrical connectors facing out. They don't need to be fitted to any particular cylinder. Just make sure each retaining ring is "unlocked." Next push each injector far enough into the fuel rail so that you can lock it with the retaining ring. If you can't push an injector into the rail, the O-ring is probably hanging up on it. Pull it out and try again. If necessary, rock the injector side-to-side slightly while pushing it in so that you can "lock" the ring.

Service of these injectors is limited to replacement of the O-rings. Don't soak the injectors in any kind of cleaning solution, as it may damage the coils inside the injectors.

Intake Manifold

The primary job of the intake manifold is to distribute the air/fuel mixture to each cylinder (just air in MPFI systems). To do this, its internal passages must be free of obstructions such as casting flash and carbon. Take a careful look in each runner for obstructions. Casting flash can be removed with a file or die grinder. Large carbon deposits typically accumulate in the exhaust passage crossover in the manifold due to the extra heat generated by the exhaust gasses.

The sealing surfaces of the manifold are also important, as they prevent vacuum, coolant, and engine oil

leaks. Dress any shallow gouges by moving a file along the length of the sealing surface. Working in the direction of the sealing surface's length helps minimize the chances of a leak. Repair deep gouges with JB Weld as described in the "Epoxy-Based Adhesives" section earlier in this chapter.

Exhaust Manifolds

To prevent an exhaust leak, the sealing surfaces of both manifolds must be absolutely flat. Dress any imperfections with a fine-toothed file, making sure to work the entire surface of the port so that it remains flat. Cracks in cast-iron exhaust manifolds can sometimes be repaired using a special welding process that preheats the manifold to a specific temperature and uses a special rod for welding. Cracks in tubular manifolds can usually be repaired with MIG or TIG welding.

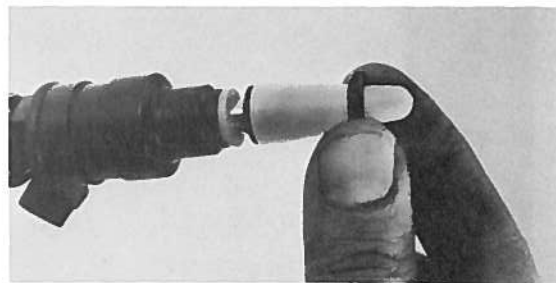
Clutch Assembly

Engines and clutch assemblies both last a long time, but if the engine is due for an overhaul, the clutch probably is, too. This is a very good idea when you consider what you had to go through to remove the engine. Consider that when the clutch goes bad, you'll have to do it all over again.

Flywheel

Flywheels are pretty durable chunks of metal. Usually, only three

things can go wrong: the ring gear teeth are chewed up as the result of a bad starter, the clutch disc surface can become warped or glazed due to a clutch (or driver) problem, or the flywheel can become heat-checked due to a slipping clutch. Your local machine shop can check for these problems and recondition most flywheels. However, if the surface of the flywheel is heat-checked, and the cracks radiate from the friction surface of the flywheel into the crankshaft flange mounting area, the flywheel must be replaced. Otherwise, it can disintegrate as you're taching out the engine—and this makes for one hell of a 35lb hand grenade!



A conical tool aids in installation of the lower O-ring on pintle-type injectors. Simply slip the cone over the end of the injector, lube the O-ring and tool with engine oil, then slide the O-ring over the tool onto the injector. With Multec injectors, just oil up the O-rings and roll them into position.

the engine's entire life. Furthermore, lithium grease contains pumice, a close relative of sand—great for hand cleaners but terribly hard on engine components. Do you really want to pump an abrasive through your engine?

Assembly Notes

Although the assembly process is fairly straightforward, you need to keep some things in mind as you proceed. Adhering to these basic tenets will help you avoid damaging parts, and possibly, your wallet.

If a part stops moving when you're installing it, don't force it. Instead, find out why it has stopped moving. Chances are it's hanging up somewhere, has slip-ped out of position, or has developed a burr that prevents its movement. Forcing a component to fit will only result in damaged parts.

If you're not sure which way an oil seal should face, remember that the lip of the seal should face the fluid it's sealing. For more information on seals, refer to the "Seals, Gaskets & Sealers" sidebar in this chapter.

Loctite thread locking compounds are recommended for some phases of engine assembly. When using these compounds, both male and female threads must be cleaned thoroughly with a chlorinated solvent, such as brake cleaner to ensure that the locking compounds will adhere to the fastener threads.

Cylinder Block Oil Gallery Plugs

If you've removed the threaded oil gallery plugs from above the camshaft, now's the time to apply automotive pipe thread sealer to their threads and install them. Be sure to wipe off any excess sealer after installation. To prevent gallery plugs from loosening, stake them in place with a chisel. Staking entails placing the edge of a chisel over the edge of the plug where it meets the block, then striking the chisel with a hammer. This flares the plug's edge to prevent it from backing out of the block. Flare each plug in two locations 180deg apart.

Crankshaft Sensor

If your engine is equipped with a Digital Ignition System, it uses a crankshaft sensor to read the position of the crankshaft. After lubricating a new O-ring with engine oil, slide it



Thread-locking compounds, such as those offered by Loctite, are a great insurance policy against loose fasteners. Just be sure the surfaces you're applying it to are free of oil and grease. A solvent such as brake cleaner can help

you out here. These are now available in chlorinated and non-chlorinated formulas. The non-chlorinated seems to work well and is easier on the environment.

over the business end of the sensor. Then slide the sensor into the side of the block and secure it with its retaining bolt.

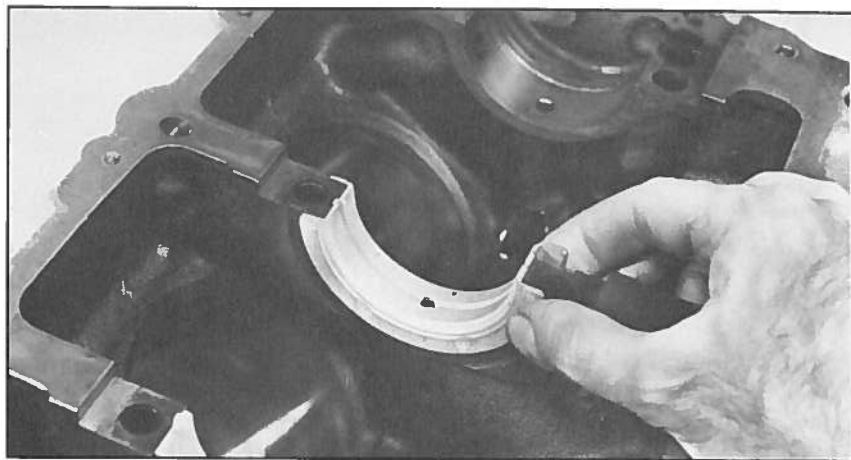
Knock Sensor

Some engines use a knock sensor located near the center of the right or rear side of the block. Apply some automotive pipe thread sealer to the threads of the sensor and screw it into the block by hand. Torque the sensor

to 14lb-ft; do not over-torque the sensor, or you will damage it.

Main Bearings

Since you've already prepped the main bearings as outlined in Chapter 5, all you need to do is check the cleanliness of the bearings one last time. Blow them off as necessary. To ensure maximum bearing life, the bearing seating surfaces in the block must be thoroughly clean as well. Re-



Make sure the main bearings you install into the block are grooved, or the crankshaft will seize from a lack of oil. Position the bearing tang into the block

first, then push the bearing into place. You can identify this bearing as the #3 bearing because it has a flange on both sides.

Seals, Gaskets, and Sealers

Seals, gaskets, and sealers can make your life great or miserable—great if they work, miserable if they don't. To increase the chances of them making your life great (or at least better than miserable) there are certain steps you can take.

Seals

Whenever you install a seal equipped with a garter spring (the coiled spring around the inside diameter of the seal), you need to make sure the spring is on the fluid side (pointing into) the engine. An example of this is a crankshaft seal. Crankcase pressure helps this type of seal to seal, and the flutes inside the seal help direct oil back into the engine. If these seals are reversed, the flutes will actually help pump the oil out of the crankcase.

For seals to live a long and happy life, you'll need to prepare the shafts that they seal against. This means the shafts should be smooth and without ridges, nicks, or burrs that could cut the seal lip. Pay special attention to the area on the shaft that the seal will contact first. Any surface irregularities here will cut the seal during its installation, causing it to leak. Minor imperfections that barely catch a fingernail can be cleaned up with 600-grit or finer sandpaper. Grooves somewhat deeper than this can be repaired with a sleeving kit.

Before you install a seal, you should always lubricate its inner lips. This prevents a dry start and consequent premature wear of the seal. Clean engine oil or light grease will do the trick. It's also a good idea to coat the outside diameter of the seal with an anaerobic or non-hardening sealer to help prevent oil from leaking from around the seal perimeter.

When installing a seal, you need to make sure that it's seated squarely into its bore. Driving the seal in evenly will help ensure that it's squarely seated.

And whatever you do, never reuse an old seal.

Gaskets

Gaskets have come a long way over the years, but two things haven't changed: The gasket mating surfaces must be clean and they must be flat to prevent a leak.

Prepare the gasket mating surfaces by cleaning them with a gasket scraper. Use a steel scraper for cast-iron or steel surfaces and a nylon

scraper for aluminum surfaces. A solvent such as Hydro-Seal II, manufactured by Gunk, can help you remove old gasket debris.

To check that the gasket mating surfaces are flat, use a straight edge, such as a ruler. If you find that the surfaces aren't straight, straighten them as necessary, using a block of wood as an anvil and light blows from a ball peen hammer.

If the gasket you're installing is made of cork and rubber, no sealer is necessary. However, you can use a light coating of non-hardening sealer to help hold the gasket in place.

Head gaskets are probably the most critical in the engine, and their life is extra difficult if the engine uses aluminum heads and a cast-iron block. Due to the different thermal expansion rates of these metals, the aluminum wants to "grow" at a faster rate than the cast-iron. This can cause the gasket to shear. However, if you use high-quality gaskets, such as those offered by Fel-Pro, and the surfaces are prepared properly, you shouldn't encounter any problems.

Be aware that the head gaskets used on the 60deg V-6 are of the composition type—that is, they're manufactured using two different materials. Steel forms the core of the gasket, giving it its strength. A soft-composition material covers both sides of the steel core and helps to seal minor surface imperfections. To avoid damaging this type of gasket, don't use any type of sealer on it.

When installing head gaskets, note their installation instructions, such as "this side up" or "up." Since the bottom surface of composition head gaskets are different than the top, proper installation is critical for a good seal. This is also true for intake manifold gaskets. With these gaskets, the "UP" side should face the intake manifold.

Sealers

Three basic types of sealers are used in engines: non-hardening, room temperature vulcanizing (RTV), and anaerobic.

- *Non-hardening sealers* are used in such places as where the oil pump pickup is fitted to the pump body and requires a clean surface for proper adhesion.

- *RTV sealer* can be thought of as a gasket in a tube, as it's used in place of a gasket rather than to seal a gasket. Although engine manufacturers don't use it as frequently as in the past, it still

has its place in engine rebuilding. Generally speaking, RTV sealer can be used as a gasket between a stamped part with a flat flange and a machined or cast part. However, you should never use RTV sealer on fuel system components because it will swell when fuel contacts it.

As with normal gaskets, the sealing surfaces must be flat and clean for best results. Since oil repels RTV sealer, you need to be absolutely sure that the surfaces the RTV sealer will contact are free of any oily residue. To do this, use a chlorinated solvent, such as brake or carburetor spray cleaner.

RTV sealer cures by absorbing moisture from the air, so it will take less time for it to cure on a humid day than on a dry day. Also, RTV sealer should not be allowed to skin over before mating the components to be sealed. If it skins over, the chances of leakage increase significantly. On average, it takes 10–15min for RTV sealer to skin over.

When selecting an RTV sealer, make sure that it's compatible with oxygen sensors. Some brands of RTV sealer emit vapors that can interfere with the operation of the oxygen sensor. These must be avoided.

- *Anaerobic sealers* are used between rigid cast or precision-machined parts where clearances are less than 0.030in. Since anaerobic sealers cure in the absence of air, you don't have to hurry during assembly. The sealer won't cure until the parts are assembled. An added benefit is that you can easily wipe away any sealer that extrudes from between the parts. Anaerobic sealers can also add strength in some situations because they eliminate movement between parts. Such is the case with chemical threadlockers.

The cure times for anaerobic sealers can vary greatly among manufacturers, ranging from minutes to hours, so you need to read the package labels carefully. Some manufacturers offer an accelerator to reduce cure times.

As with the other types of sealers, the surfaces to be sealed must be cleaned with a chlorinated solvent and be free of any debris, including old anaerobic sealer, to ensure best results. This can be a little tougher than you think, because when anaerobic sealer dries, it becomes clear. So clean the mating surfaces carefully, and don't smear the sealer when mating the parts.

move all dirt, grime, and oil by spraying the seating surfaces with carb or brake cleaner and letting them air dry. Remember, clean bearing backs and saddles maximize heat transfer.

Begin installing the main bearings by placing the grooved bearings into the block. This is important as the grooves supply lubricating oil to the bearings. If you put the plain bearings into the block, the crankshaft will seize almost immediately after the engine is started. As you install the bearings, make sure that the tang on the edge of each bearing fits into the square relief in the bearing saddles and that the bearings are fully seated.

Remember that in engines with small-journal crankshafts, the #1 bearing looks like the #2 bearing, except it's wider. The #3 bearing takes up the crankshaft thrust, and therefore has short sides, and the rear main bearing is the widest. Engines with large-journal cranks use identical bearings for the #1 and #4 main bearing journals. The #2 bearing is the narrowest, and the #3 bearing has thrust flanges on its sides. Install the bearings in the main bearing caps following this procedure as well.

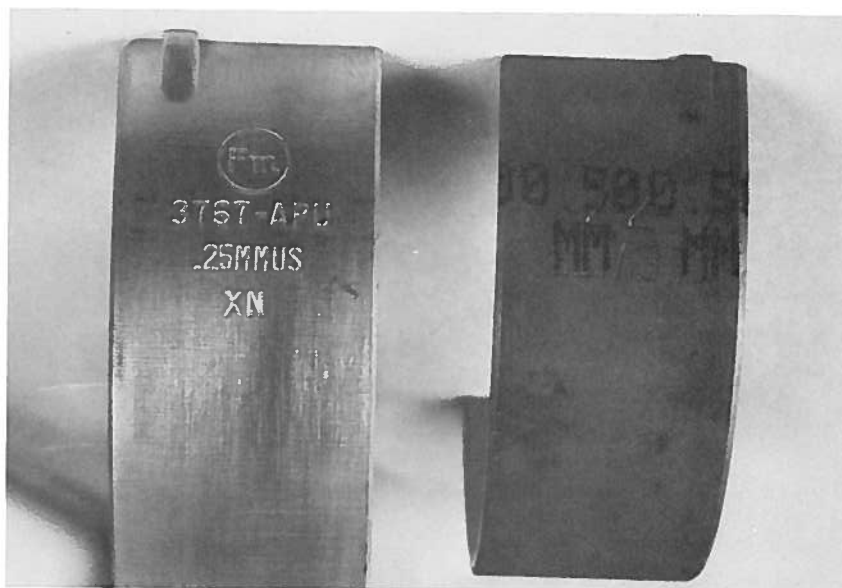
Crankshaft

After installing the main bearings into their proper locations in the block and bearing caps, install the crankshaft. To give you a handle by which to grab the back of the crank, insert one or two of the flywheel bolts. Be sure they're screwed in far enough that they don't fall out of the crank.

Now slowly lower your cleaned crankshaft squarely into the block. When the crank is in the block, don't rotate it, as you'll damage the finish on the main bearings. And don't lubricate the crankshaft or bearings just yet, because you first need to measure bearing clearance.

Measuring Bearing Clearance

If you don't have access to micrometers and snap gauges, or don't know how to use them, you can use Plasti-Gage to measure bearing clearances. Plasti-Gage is a precision extruded plastic that compresses at a controlled rate. This material is easier to use than micrometers and snap gauges and is probably more accurate in unskilled hands. It's also the only way main bearing clearances can be measured with the crankshaft in the engine. Two types of Plasti-Gage are



If your crankshaft was ground undersize, you'll need to use undersize bearings. The main bearing on the left is for a crankshaft that was ground 0.25mm

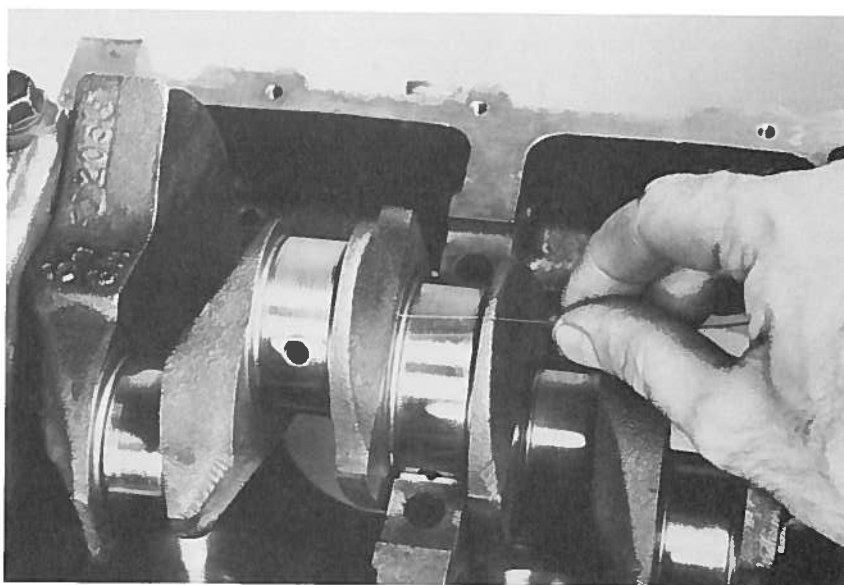
undersize, as evidenced by the stamped ".25MMUS" marking. The rod bearing on the right is for a crankshaft that's been ground 0.500mm undersize.

typically used during an engine rebuild: 0.001-0.003in (green) and 0.002-0.006in (red).

After Plasti-Gage is compressed, its width is compared to the scale on the outside of its envelope. When the thickness of the compressed Plasti-Gage matches the width of one of the bars on the envelope, the number on

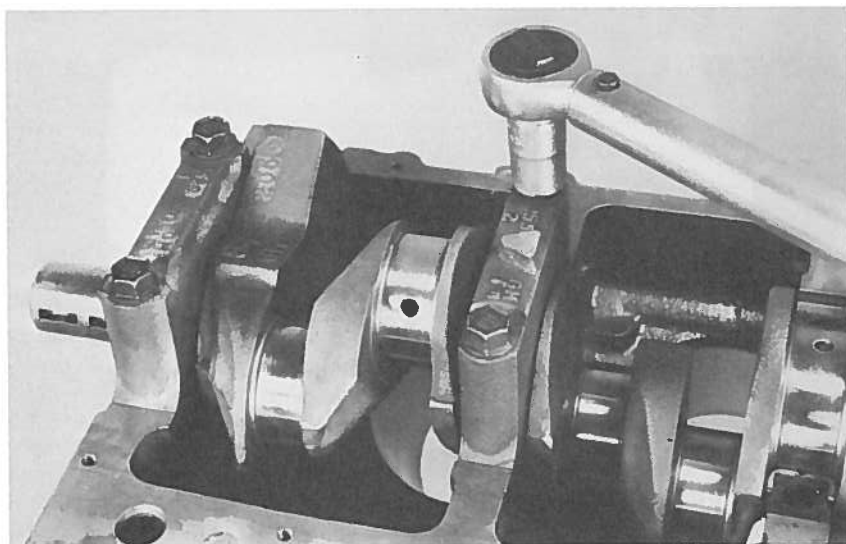
the envelope scale indicates bearing clearance.

When the bearings and journal are clean and dry, lay a piece of the green Plasti-Gage across the width of the journal (or across the lower bearing if the engine is in the vehicle). With the Plasti-Gage in position, lower the main bearing cap into the



If you don't have access to micrometers and snap gauges, Plastigage can provide you with fairly accurate clearance measurements. To help prevent the

Plastigage from moving when you install the bearing cap, use a piece long enough that you can hold it across the bearing journal as you install the cap.

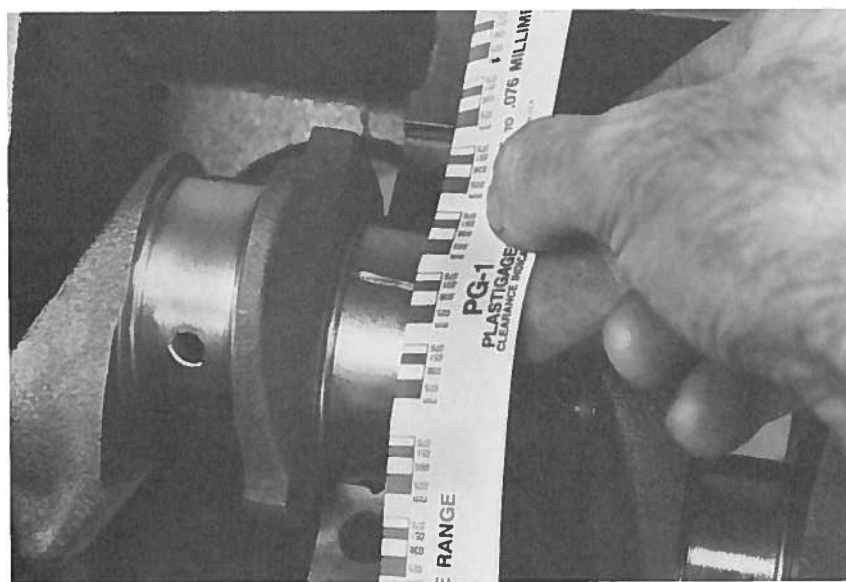


Make sure the arrows on the bearing caps are pointing toward the timing chain and are in the proper numerical positions, then tap the caps into place with a soft-faced mallet. Don't draw the caps into position with the bolts, as you can damage the caps or the block. Af-

ter lubricating the bolt threads and the underside of the bolt heads with clean engine oil, install the bolts and Torque them to specifications. Then remove the bolts and cap so that you can measure the Plasti-Gage.

block, taking care not to shift the Plasti-Gage. Use a soft-faced mallet to seat the caps into the block. Don't be tempted to use the bolts to pull the

cap into the block, as you can damage the cap and/or block. Just tap the cap hard enough to fit it into the notches in the block.



Match the width of one of the bars on the Plastigage scale to the widest area on the compressed Plastigage to determine minimum bearing clearance. By measuring the narrowest area on the Plasti-Gage, you can determine maximum clearance. If you had the crank-

shaft ground so that an extra 0.001in remained, as was recommended in the Reconditioning chapter, the clearance should be 0.0015-0.0025in. This will help prevent excessive oil pressure losses at the main bearings.

Now lightly lubricate the threads and the underside of the heads of the bearing cap bolts with engine oil (this makes for an accurate torque reading). Then slide them through the cap and tighten them by hand. Next, torque the bolts to 70lb-ft, then loosen and remove them. Finally, remove the bearing cap from the block. The compressed Plasti-Gage will remain on the crankshaft journal or on the lower bearing.

To determine minimum bearing clearance, measure the compressed Plasti-Gage at its widest point by matching the width of the Plasti-Gage with one of the bars on the envelope scale. To determine maximum bearing clearance, measure the Plasti-Gage at its narrowest point using the technique described above. Compare these clearances with the specifications listed at the back of this book. If the clearances are out of specification, check them once again.

If your second check reveals that the clearances are 0.0005-0.001in larger than specifications, and the crankshaft has never been ground, you can order bearings that are 0.001in thicker than the stock bearings from your local GM dealer. If you use both halves of these thicker bearings, clearance will decrease 0.001in. If you use just one of the bearing halves, you will decrease clearance by 0.0005in. This "selective fitting" of bearings is done at the factory as well as at GM dealers, and works well.

However, if clearances are beyond maximum or below minimum specifications, and using the factory undersize bearings won't help you, the crankshaft will have to be ground and new bearings fitted. As noted in Chapter 5, you should ask to have the main journals ground so that 0.001in "extra" material remains. This will reduce oil pressure loss within the engine and increase its life.

After you've finished measuring the journals, remove the Plasti-Gage from the bearings or crankshaft to prevent damage.

Once the clearances are within specifications, remove the crankshaft and lubricate the upper and lower main bearings with assembly lube or EOS. Lubricate the thrust flanges of the #3 bearing after measuring crankshaft end play. Now install the crankshaft into the block, and position the main bearing caps onto the block, one at a time. Make sure they're in the right position on the block, their ar-

rows point toward the timing chain, and that they fit snugly into the notches in the block. Next slide the main bearing cap bolts into the caps and screw them into the block by hand. Screwing the bolts into the block a turn or two will help align the bolt holes in the cap to the block. Use a soft-faced mallet to gently tap the caps into position.

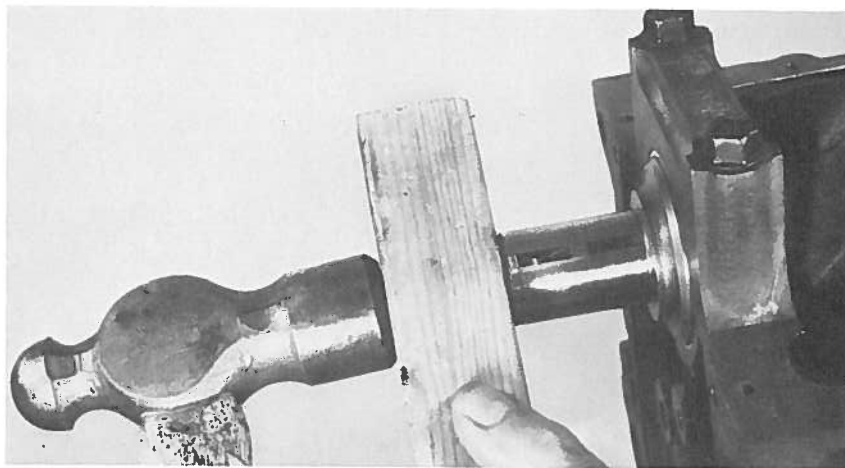
With the caps on the block, don't tighten the retaining bolts just yet. If you do, and the bearings aren't correctly aligned with the block, excessive wear will result. You must also measure crankshaft end play.

Measuring Crankshaft End Play

The first step in measuring crankshaft end play is to align the bearing caps with the crankshaft. This entails sliding a large screwdriver or pry bar between the block and the crankshaft front counterweight and giving the crank a good push to the back of the block. To align the rear thrust surface of the #3 main bearing, slide the pry bar between the block and the crankshaft rear counterweight and forcefully push the crank forward. This ensures that both upper and lower thrust flanges share the load from the crankshaft equally. Then release the pressure and torque the bearing cap bolts to specifications using at least three passes, such as torquing them all to 30lb-ft, then to 50lb-ft, and finally to 74lb-ft. With the bolts torqued, lever the crankshaft forward and measure the clearance between the front thrust face on the #3 bearing and the flange on the crankshaft. If clearance is less than specifications, the thrust faces on the crankshaft must be ground. If the clearance is greater than specs, the thrust flange on the crankshaft must be built up by welding and then machined to size. After checking crankshaft end play, you'll have to remove the bearing cap bolts, bearing caps, and crankshaft so that you can install the 5mm wide one-piece rear main seal. If your engine uses the 10mm wide one-piece seal, install it with the crankshaft in position in the block.

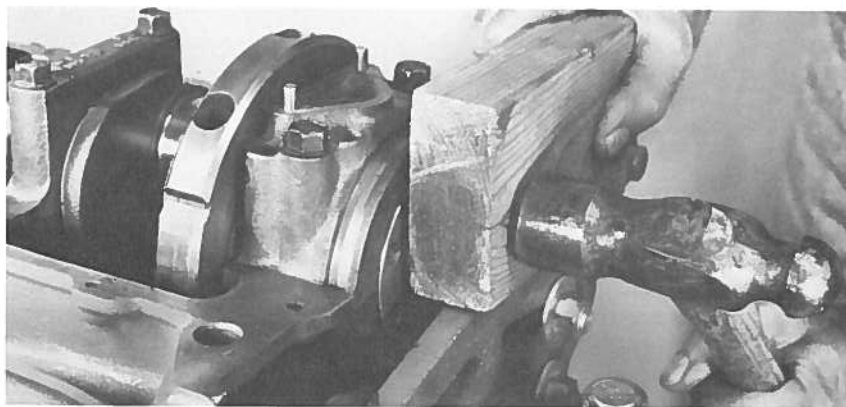
Rear Main Seal Installation

Installation of the rear main seal is a job that shouldn't be rushed, because if the seal leaks, the engine must be separated from the transmission to replace it. Begin seal installation by making sure the area on the



A block of wood and a hammer can be used in lieu of a pry bar to align the bearings. Place a block of wood against the crank and then hit it sharply with a hammer. Always tap against the ends

of the crank rather than against one of the counterweights, as you're less likely to damage the crankshaft. Also, there's less chance of getting residue from the wood block into the engine.



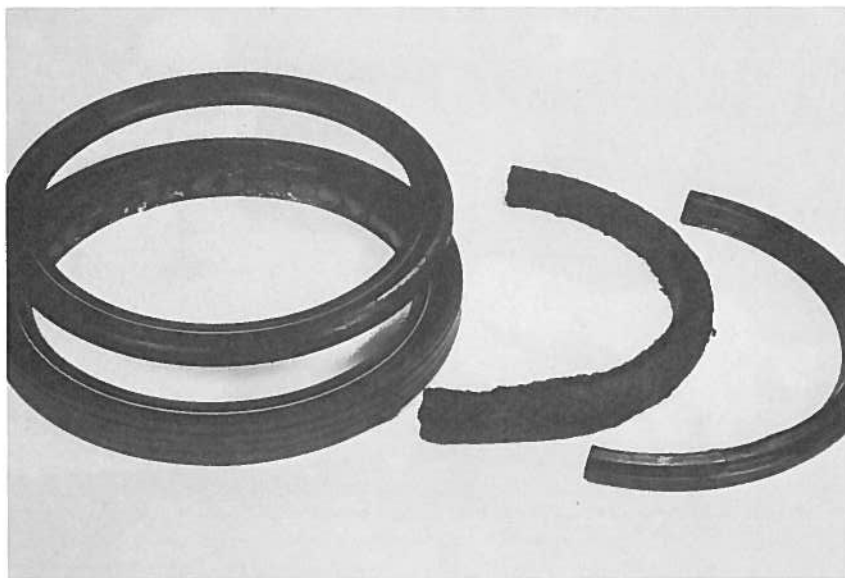
After tapping the crankshaft backwards, proceed to the rear of the crank and tap

it forward. This will align the bearings and thrust surfaces.



To measure crankshaft end play, force the crankshaft forward and hold it there while placing a feeler gauge between

the front of the thrust bearing and the crankshaft.



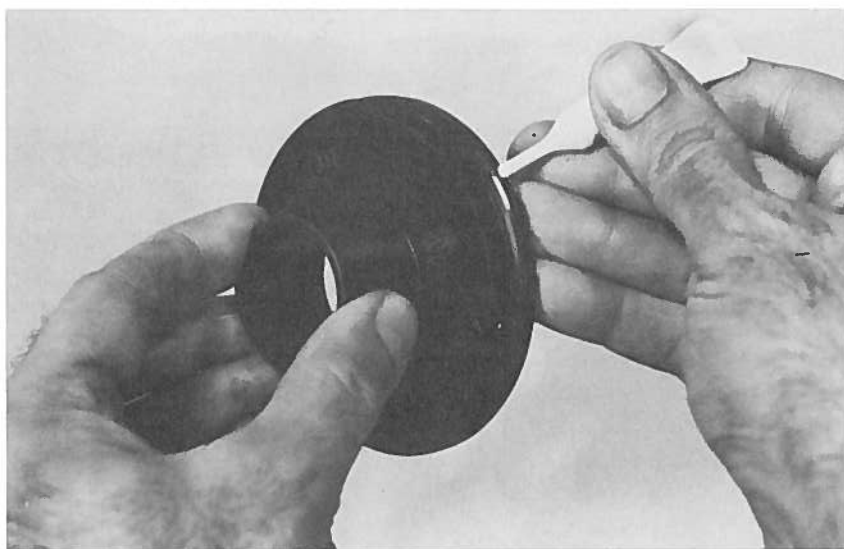
Four types of rear main seals have been used on the 60deg V-6. In chronological order they are: two-piece rope-type, two-piece lip-type, 5mm one-piece lip-type, and 10mm one-piece lip-type. If your engine was fitted with ei-

ther of the first two seals, throw them out and use the 5mm one-piece seal. The 10mm seal is used on all large-journal cranks and can be installed with the crankshaft in position.

crankshaft that the seal rides against is free of burrs, nicks, or gouges as these will accelerate seal wear. Refer to the "Seals, Gaskets, and Sealers" sidebar in this chapter for more information.

Four types of rear main seals are

used on the GM 60deg V-6, depending upon the model year. The engine began its life with a rope-type seal. This seal was used for all small-journal cranks, which includes all 1980-1984 engines, as well as some early-1985 versions. A two-piece neoprene seal



Be sure to lubricate the seal lips before installing the seal on the installation tool. Then clean the entire perimeter of the seal with a rag wetted with chlorinated solvent. This will prepare the seal

for a thin coating of sealant which is applied to the entire perimeter of the seal. No special tool is needed for the 5mm seal.

was offered as a service replacement, but its sealing qualities left something to be desired. To remedy this situation a 5mm wide one-piece neoprene seal was offered as a replacement and was much more reliable than either the rope-type or two-piece neoprene seal. Fortunately, this seal fits into the groove that was occupied by the rope-type seal without any modifications. Just make sure you drop the crank straight into the engine to avoid gouging the seal.

When large-journal cranks came into use in the middle of the 1985 model year, all were fitted with a one-piece neoprene seal. However, the block was modified and the width of this seal was increased to 10mm to make installation easier and reduce the chances of an oil leak due to assembly problems. One great feature of this seal is that it can be replaced without removing the crankshaft. This seal was still being used when this book was written.

Since all lip-type rear main seals use crankcase pressure to help them seal, they need to be installed so that the garter spring around the seal's inner diameter faces the inside of the engine. If the crankshaft seal is installed backwards, it'll actually cause oil to be pumped out from around the crankshaft.

5mm and 10mm Seal Installation

Installation of a one-piece seal requires the use of a special tool that is usually included in the gasket set and allows you to mount the seal without damaging its lips. Begin by lightly lubricating the inner lips of the seal with assembly lube, then sliding the seal onto the tool. Make sure that the garter spring on the seal will point into the engine when you install it on the crankshaft.

You also need to lubricate the entire rear main seal area on the back of the crank with a *thin* coat of assembly lube. If you put too much on and it gets into the seal pocket in the block, the adhesive/sealant you'll be putting on the outside of the seal won't work, and you'll end up with a leak. Next, spray a rag with a little bit of brake cleaner and wipe the perimeter of the seal to ensure there's no oil to upset the bonding of the sealant. With the seal cleaned, apply a 1/16in bead of adhesive/sealant to the perimeter of the seal. Be sure to leave no gaps in the sealer, or the seal will leak. Now,

with the crankshaft out of the engine, slide the installation tool over the back of the crank and carefully slide the seal off the tool, onto the crank. Then remove the tool.

Turning your attention to the block, use brake cleaner to clean the rear main seal pocket and the surface of the block where the main bearing cap will sit. Again, this ensures the proper bonding of the adhesive/sealant. Just avoid getting the cleaner on the bearings, as you'll remove the lubricant you applied after measuring the main bearing clearances.

Now grab the crank and hold it over the block so that you can assess the position of the rear seal. Adjust its position so that it will fit into the seal pocket (rear-most groove) in the block. Then squarely lower the crank into the block without touching the adhesive on the seal.

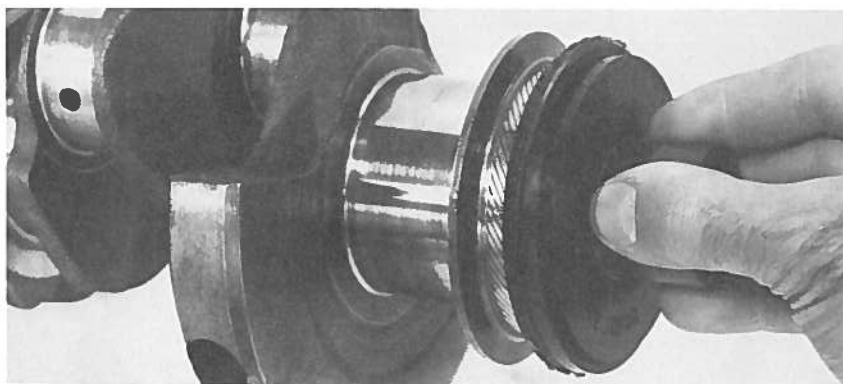
Some early blocks and all late-model blocks use an O-ring to seal the rear main bearing cap to the block to reduce oil leakage between the cap and the block. This O-ring should be installed without any sealer to prevent it from slipping out of position.

With the crank in the block, apply some anaerobic sealer to the rear main bearing cap mating surface in the block. Just like the O-ring above, use of anaerobic sealer prevents oil from leaking from between the cap and block. Apply a 1/8in diameter bead just inside both notches in the block.

After applying the anaerobic sealer, fit the rear main bearing cap to the block. To help you align the cap to the block so that you don't disrupt the sealer on the seal, slip the cap bolts through the cap. Then while holding the cap away from the block, screw the cap bolts loosely into the block. Finish the job by sliding the cap down into position.

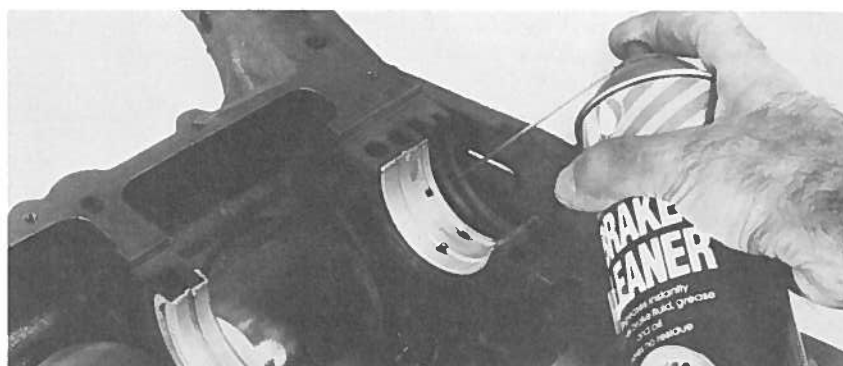
When the cap is between the notches in the block, lightly tap it into position with a soft-faced mallet. Next, use a soft-faced mallet to install the rest of the main bearing caps. Be sure the caps are in the right position and the arrows are pointing toward the timing chain end of the block. Then install the remaining cap bolts finger-tight. When the bolts are in position, align the bearings to the crankshaft following the procedure you used to measure crankshaft end play.

Finally, torque the bolts to specifications, starting with the #2 or #3 bearing cap and working your way



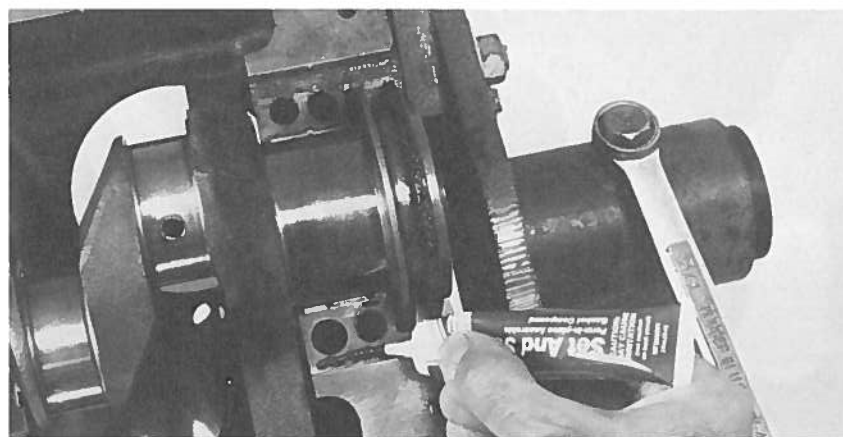
Before slipping the seal onto the crank, lubricate the sealing surface on the crank with assembly lube. The knurling on the back of the crank helps move oil away from the seal when the engine is running. Use the tool to mount the seal

on the crankshaft. The tool protects the seal lips from cuts. Carefully slide the seal off the tool so that the seal is properly positioned to fit into its groove in the block.



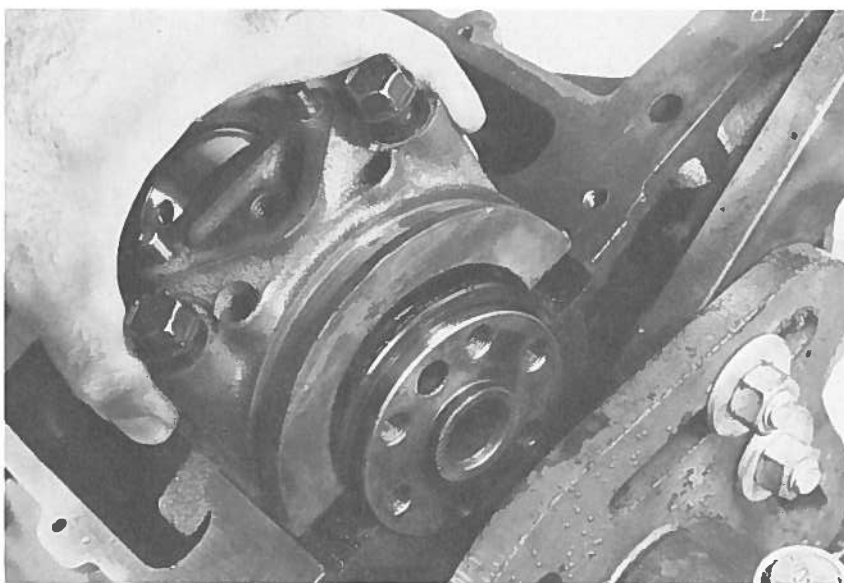
Be sure to clean the seal groove in the block and in the rear main bearing cap with a chlorinated solvent. This will allow proper bonding of the sealer you've installed on the perimeter of the rear

main seal. Clean the rear main bearing cap mating surfaces with the solvent as well, as this will ensure a leak-proof seal.



Anaerobic sealer is required to prevent oil from seeping out between the bearing cap and block. After applying a 1/8in-diameter bead, carefully spread it

out between the bearing cap notch in the block and the cap bolt holes, as shown.



Use the cap bolts to help you align the rear main bearing cap with the block.

This will help you avoid accidentally wiping the sealer off the rear main seal.

out to the ends of the block. Torque the bolts in three passes, such as torquing them all to 30lb-ft, then to 50lb-ft, and then finally to 70lb-ft. Torquing the bolts in three passes helps increase torquing accuracy.

After you've installed the crankshaft, screw the bolt into the front of the crank and rotate it a few revolutions. The crank should turn smoothly and rather easily. If it becomes hard to turn at any point, the bearings may be dirty, the crankshaft could be nicked, or the thrust surfaces on the #3 main bearing may not be properly aligned to the crankshaft. You can locate the source of the problem by loosening the main bearing

cap bolts one pair at a time and checking the amount of torque it takes to rotate the crank. Then torque these bolts to specifications and loosen the next pair of bolts. If loosening one pair of bolts results in a significant decrease in the torque it takes to rotate the crank as compared to the other pairs of bolts, you've found the source of the problem.

If the crankshaft rotates freely after you loosen the bolts for the #3 bearing cap, and the bearings and crankshaft look fine, align the thrust surfaces of the bearing following the method earlier outlined in "Measuring Crankshaft End Play" in this chapter.

Measuring Rod Bearing Clearance

Rod bearing clearances are measured using the same method you used for the main bearings. However, don't put any rings on the pistons, so you can just slip each piston into its bore. To ensure that your bearing clearance readings are accurate, clean off all contaminants on the bearings or the rod journals on the crankshaft, using chlorinated solvent.

Begin by installing a bearing insert into the connecting rod and cap for which you want to check clearance. If your crankshaft was ground undersize, remember to use the appropriate undersize bearings.



When installing the bearings, make sure that the bearing tang fits into the notch in the rod or cap. Also keep in mind that the rod cap should be installed so that its bearing tang is on the same side as the bearing tang on the connecting rod.



To help guide the rod bolts over the crankshaft journal, slip an 8in length of 3/8in ID fuel line hose over each bolt.

Slip the hoses over the bolts far enough to help hold the bearing in place.

To protect the crankshaft journal and cylinder bore from being damaged by the rod bolts, slip an 8in length of 3/8in ID fuel line hose over each bolt. Push the hose on far enough so that the bearing can't fall out of the rod. Now you can slip the piston into its appropriate cylinder while making sure the hoses guide the rod onto the crankshaft journal. When the bearing is against the crankshaft, remove the hoses. Then lay a length of green Plasti-Gage across the rod journal, directly above the connecting rod.

With the cap oriented to the rod so that the bearing tang in the rod and cap are on the same side, slide it over the rod bolts. Take care not to knock the Plasti-Gage out of position. When the cap is seated, screw the nuts onto the bolts and torque them to specifications.

Before you remove the rod cap, slide the rod to one side of the journal and measure rod side-clearance. The thickest feeler gauge that fits in between the side of the rod cap and the crankshaft indicates rod side clearance. Now remove the rod nuts and rod cap. You may need to rock the rod cap back and forth slightly as you pull it off the rod bolts, or you can use a brass drift against the flanges on the cap to remove it.

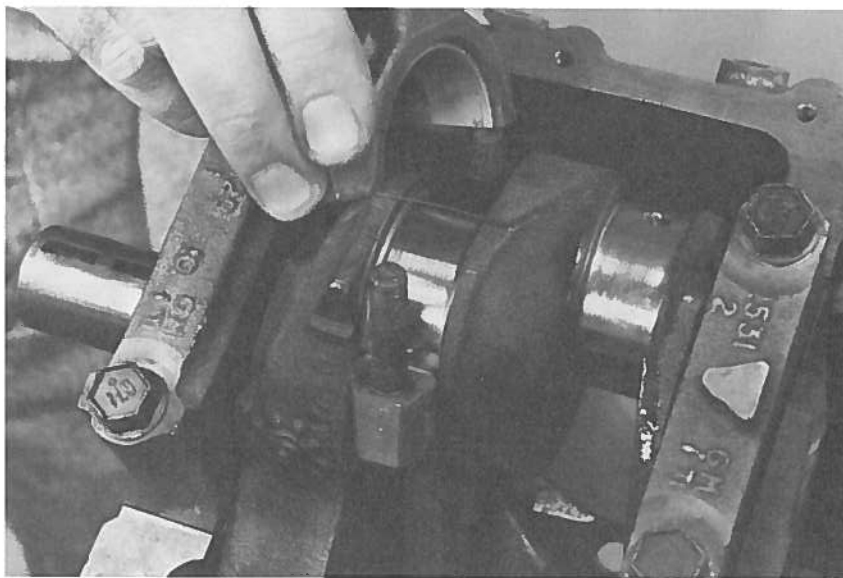
When the cap is off, measure the widest and narrowest sections of the Plasti-Gage with the scale on the envelope. If clearance is too great, the rod journal will need to be ground and undersize bearings used. And to keep the engine properly balanced, the machine shop will grind all rod journals to the same dimension. If clearances are smaller than specification, your machine shop can hone the big end of the rod to gain more clearance.

Pistons and Rings

If you want your rebuild to last as long as possible, seek out quality piston rings, such as those offered by Sealed Power. These first-class rings feature stainless-steel oil rails and moly-filled inlays on the top compression ring. Whichever rings you choose, avoid hard-chrome compression rings as they take forever to seat.

Ring Installation

With the ring end-gaps set (see "Adjusting Ring End-Gap" section, Chapter 5), you can begin installing the rings. Remember, the top compression ring is thinner than the sec-



With the Plasti-gage laying across the width of the journal, slip the correct rod cap over the bolts. Make sure the bear-

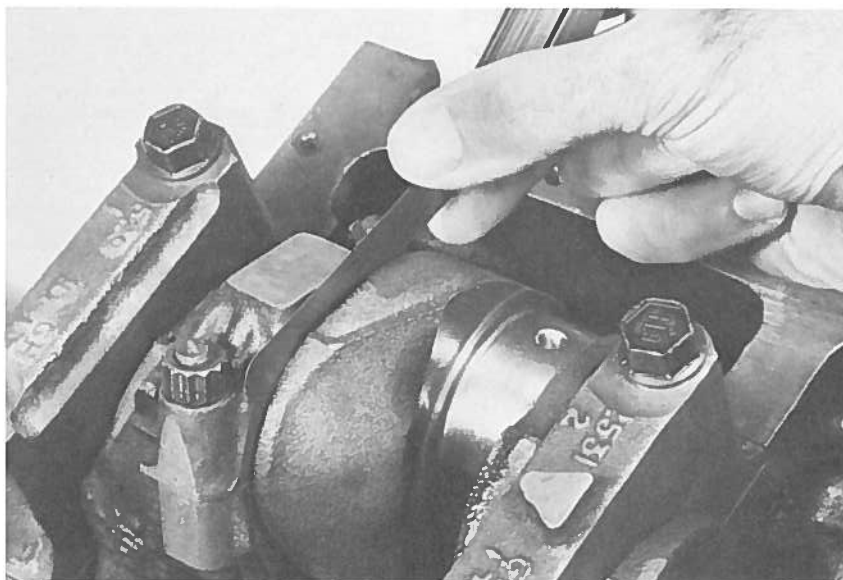
ing tang in the rod and cap are on the same side and that the Plasti-gage doesn't move.

ond compression ring. If during ring installation you find that a piston ring has a considerable amount of side clearance or it's too thick to fit into the piston groove, it's probably in the wrong position on the piston.

Also keep in mind that compression rings are designed to face in a certain direction to work properly. To ensure that you know which direction

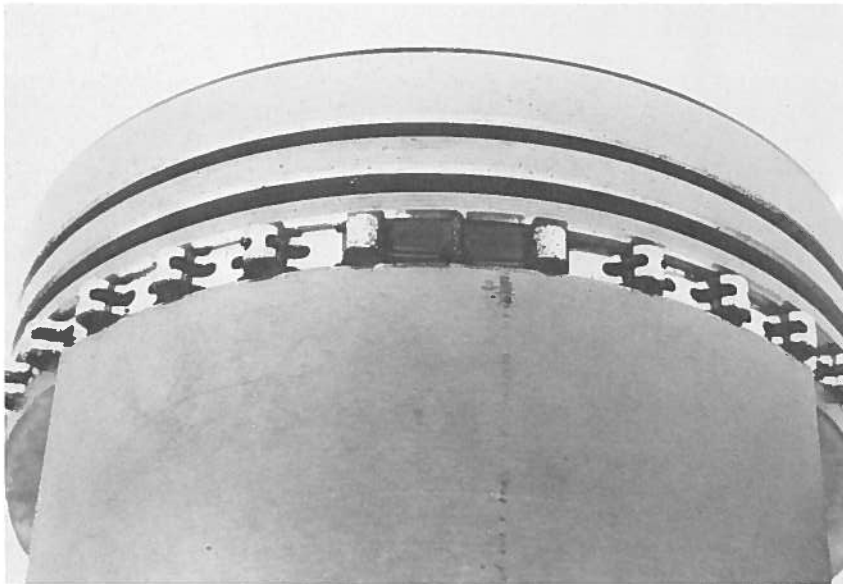
the rings need to face, piston ring manufacturers usually put small dimples called "pip marks" on compression rings. Alternatively, they may use other markings also, such as "TOP," "T," or "UP" instead of pip marks.

When you install the rings on the piston, the pip marks must be on the top side of the ring for the ring to



To save time, measure rod side clearance before you remove the connecting rod cap. The feeler gauge fits in be-

tween the side of the rod cap and the rod journal.



This expander ring from Sealed Power uses different-colored nylon blocks on

its ends. This helps prevent the ends of the ring from overlapping.

work properly. However, in some cases, this "golden rule" of ring installation doesn't hold true, so follow the installation instructions that came with your piston rings. If your rings aren't marked, just remember that the chamfered edge on the inside of the ring always faces up on the top compression ring and down on the second compression ring.

You also need to make sure that you're putting the rings that you mea-

sured for a particular cylinder on the correct piston. All your measuring and adjusting of ring end-gaps could go down the tubes, because all of the cylinders may not be the same dimension, even if they were bored and honed on the same machine.

Once you've identified which ring goes where and which side faces up, you can install them. Just remember that the rings have to be spread to fit over the piston, and that compression

rings can be quite brittle. Consequently, you should only spread them far enough to facilitate installation; otherwise, they may crack. On the other hand, you need to spread them far enough so that they don't scratch the piston.

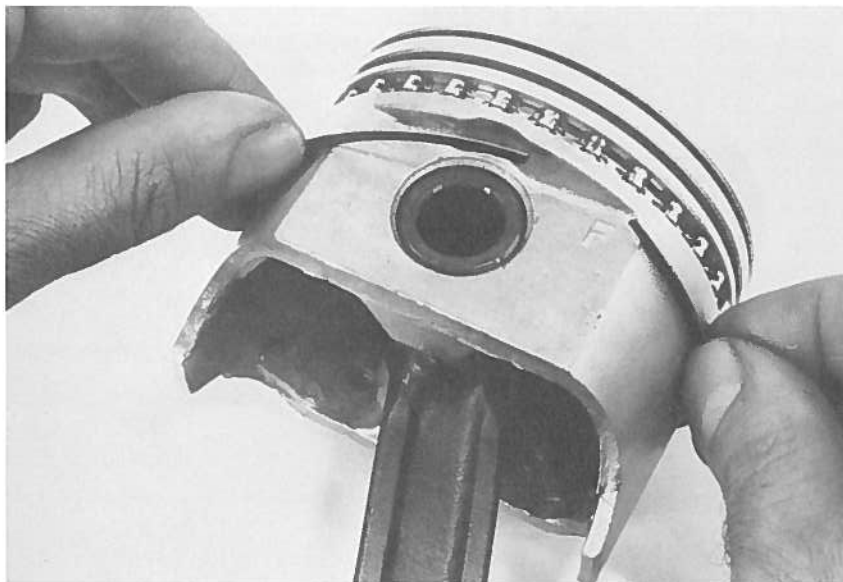
With this "balancing act" in mind, begin by installing the circumferential expander (the wavy ring) into the lowest groove in the piston. You'll notice that the ends of the expander are painted different colors or use different colored nylon blocks to help you ensure that the ends of the expander are butted against each other and not overlapping. If the circumferential expanders you're using are marked like this, note their positions and make sure they haven't moved after you've installed the oil rails. If the ends overlap, you won't be able to fit the piston assembly into the block.

With the expander in place, turn your attention to the oil rails. Since oil rails don't have any specific orientation, you can install them with either side facing up. Begin by slipping one of the rails over the end of the connecting rod. Carefully slide it up the skirt until it's near the bottom of the expander. Now insert one end of the rail into the space directly underneath the expander and "wind" the rail into this space, using your thumb and forefinger. Make sure that the ends of the expander remain butted. Install the remaining oil rail into the space just above the circumferential expander using this same method.

When you've finished installing both oil rails, take one last opportunity to make sure the ends of the expander are butted up against each other. If they're overlapping, you'll have to remove the rings and start over.

You can install the compression rings with your hands or a piston ring expander. A piston ring expander is basically a set of pliers with a cup on each jaw. These cups "trap" the ends of the piston ring, giving the pliers something to push against to expand the ring.

If you elect to use a piston ring expander, dress the inside tips of the cups with a file so that they won't scratch the surface of the piston when you're installing the rings. And remember to expand the rings only far enough to get them into position on the piston, or you may fatigue or break them.



You'll need to wind the oil rails into position. Two rails are used: one above the expander and one below it. The lower oil rail is installed from the bottom

of the piston. Keep the ends of the rail over the recessed area on the side of the piston to prevent scratching the piston skirt.



In this photo, a piston ring expander is used to install the second compression ring. Since ring compressors don't pro-

vide much tactile feedback, take care when using one, or use your thumbs to expand the rings.

Begin installation of the second compression ring from the top of the piston. Ensuring that the pip mark(s) is pointed upward, cradle the piston using the fingers from both hands and slowly spread the ends of the ring with your thumbs. Spread the ring just far enough to slide it over the top of the piston onto the top ring groove.

To get the ring into the lower groove, cradle the piston with your fingers once again. Then, while spreading the ring with your thumbs, use your forefingers to slide the back of the ring down into the lower groove. Finally, spread the ends of the ring one more time so that you can slide the front of the ring into the groove.

Install the top compression ring using this same technique. Just be sure that the pip mark is pointed toward the top of the piston.

When you've installed the rings, try to rotate them with your hand. They should rotate in their grooves freely, with practically no drag whatsoever. If not, check for burrs in the piston ring groove. The rings must rotate freely in their grooves before you install the pistons into the block.

Ring Orientation

A piston ring is designed to rotate to prevent it from sticking in its groove due to carbon build-up. No one really knows how much they rotate, but they need to be oriented in a specific way during assembly. This mini-

mizes the chances of the end-gaps lining up, which would allow cylinder pressure to blow past the rings into the crankcase, and with it, horsepower.

For proper piston ring end-gap orientation, refer to the accompanying illustration.

Although orienting piston ring ends gaps is easy, you need to pay extra attention to the oil rails and expander. The problem is that as you rotate one of the oil rails, the pressure exerted by the circumferential expander on the other rail causes it to turn also. So you need to double check the orientation of the oil rail end-gaps after setting them.

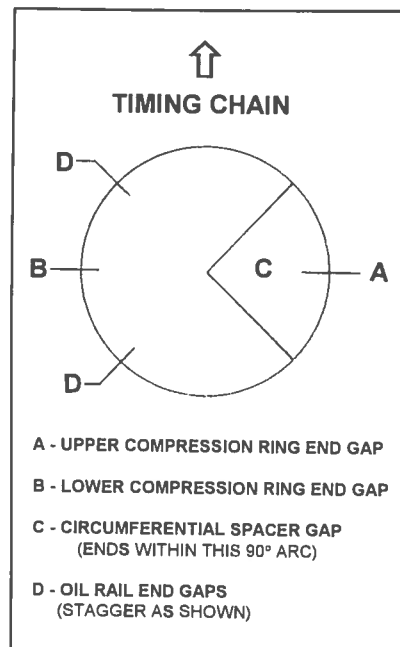
Piston Installation

After orienting all the rings on the pistons properly, you can begin installing the pistons into the cylinder block. If the block is on an engine stand, rotate the block so that the cylinders of one bank are positioned vertically. This makes it easier to install the piston assemblies. Also, be sure to put the proper piston in each cylinder: piston #1 in cylinder #1, and so on.

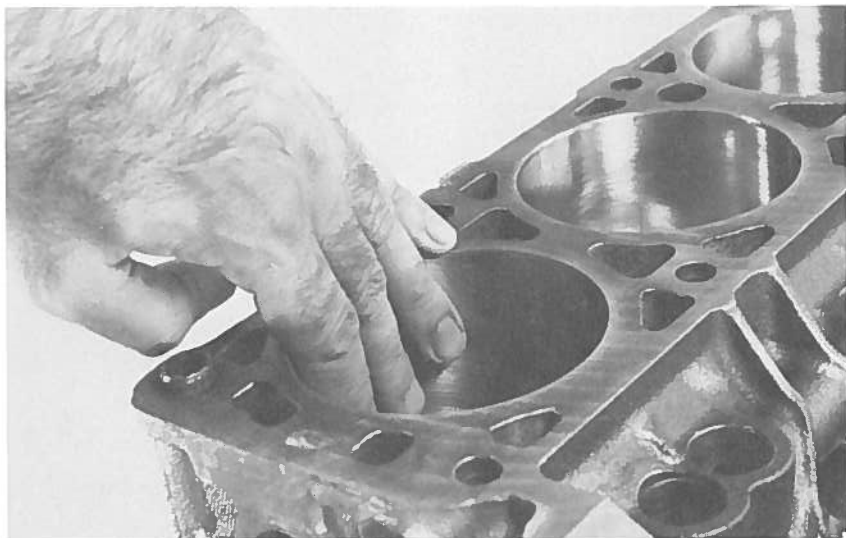
To install the piston assemblies you need some means of compressing the piston rings. Unless you're in the business of rebuilding engines professionally, the most cost-effective way to do this is with a band-type piston ring compressor (available for a few



By cradling the piston with your fingers and expanding the ring with your thumbs, you can easily install the rings.



Piston rings have to be oriented in a specific way to maximize power and minimize oil consumption. The chart above illustrates which ring faces in what direction.



Be sure to lubricate the cylinder, piston skirt, and ring compressor before attempting to install the piston. Assembly lube or GM EOS is what you should

use, as it clings to the parts much longer than engine oil, preventing excessive wear.

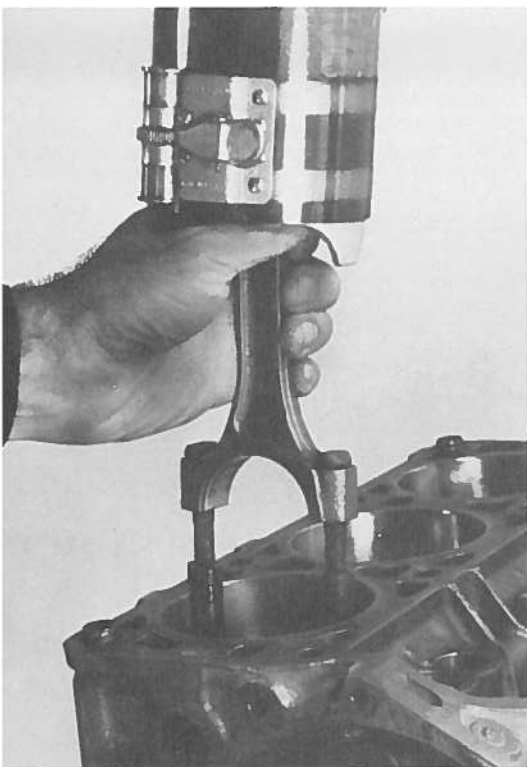
screwdriver with a large tip is more useful for turning the "key hole." With it, you can tighten the clamp more quickly and control the band's release more accurately by letting the screwdriver handle slowly slip from your grip.

Before putting a compressor on a piston assembly, lubricate it, the cylinder, and piston skirt lightly with assembly lube or EOS. In the past, the recommended way to lubricate a piston assembly before installation was to dip the entire piston (with rings) into a can of oil or EOS. However, that thinking has changed. We now know that dipping the entire assembly puts an excessive amount of oil on the face of the piston rings, which impairs the seating of the rings to the cylinder. The preferred technique is to dab your fingertips in the lubricant and then lightly coat the piston skirt and the upper and lower surfaces of the rings while avoiding the ring faces.

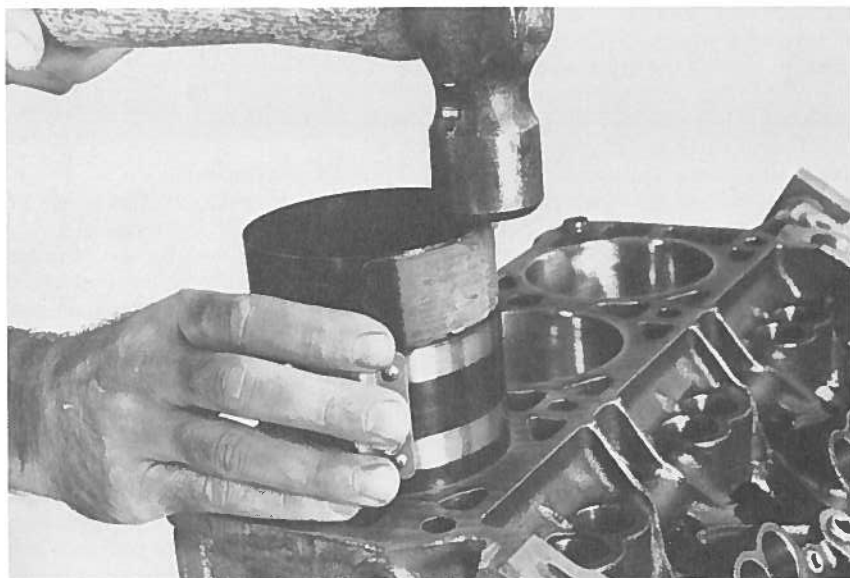
With everything correctly lubed, position a rod bearing into the rod. Then slide an 8in length of 5/16in ID fuel line hose over each connecting rod bolt. This will help guide the rod over the crankshaft journal and keep the rod bolts from damaging it. Be sure to apply assembly lube to the wear surfaces of the upper and lower bearings. You should also rotate the crankshaft so that the journal for the cylinder you're working on is at the

dollars, at both Sears and auto parts stores). These compressors use a large band to contain the piston and rings. Smaller bands on the outside of the larger band are used as drawstrings to compress the whole affair. A ratcheting lever keeps tension on the small bands.

Although these compressors come with a square key to tighten and loosen the small band, a flat-bladed



Don't cover the lower portion of the piston with the ring compressor because this area will help guide the piston into the cylinder. As you slide the piston into the cylinder, make sure the rod bolt hoses fit over the crankshaft journal. The mark on the piston dome must point toward the timing chain end of the engine.



To keep the rings from popping out between the bottom of the ring compressor and the top of the cylinder, seat the com-

pressor on the block by lightly tapping around its perimeter with a hammer.

bottom of its stroke.

After checking the orientation of the piston rings one last time, expand the compressor and slide it over the piston so that it covers the entire piston except the lower 1/2in or so. This area will help guide the piston into the cylinder bore. Tighten the compressor around the piston, but don't rotate it or you'll upset the positioning of the piston ring end-gaps.

Next position the piston in the proper cylinder, making sure that the mark on the top of the piston points toward the front of the block and that the hoses on the rod bolts fit over the crankshaft journal. To ensure that the compressor is fully seated on the block, lightly tap it around its entire perimeter with a hammer. With the compressor fully seated, hold the compressor tightly against the block while you lightly tap the piston into the cylinder, using a hammer handle.

If the piston stops moving, stop tapping. Chances are a piston ring has probably snuck out between the compressor and the top of the block. If you try to tap the piston in, you'll probably break the ring, damage the cylinder, or both. Release the compressor, slide it back over the rings, and start again.

Once the top of the piston is even with the top of the block, remove the compressor and slowly push the piston down until the rod bearing is seated against the crankshaft journal. After making sure the bearing tang on the rod and cap are on the same side, slip the cap over the rod bolts. Rocking the cap back and forth will allow you to install the cap as completely as possible onto the bolts. Finally, spin the nuts onto the rod bolts and torque them to specification.

Follow this process to install the remaining piston assemblies, thus completing the short block assembly. After you install each piston assembly, it's a good idea to rotate the crank a revolution or two. That way, you'll be able to identify the source of a problem if the crankshaft doesn't rotate smoothly. If you do experience a problem, try sliding the rod back and forth on the crankshaft. If it doesn't slide freely, the problem lies in the bearings or crankshaft. Look for any signs of foreign debris or nicks in the bearings or on the sides of the crankshaft.

Assembly Check

After you've assembled the short



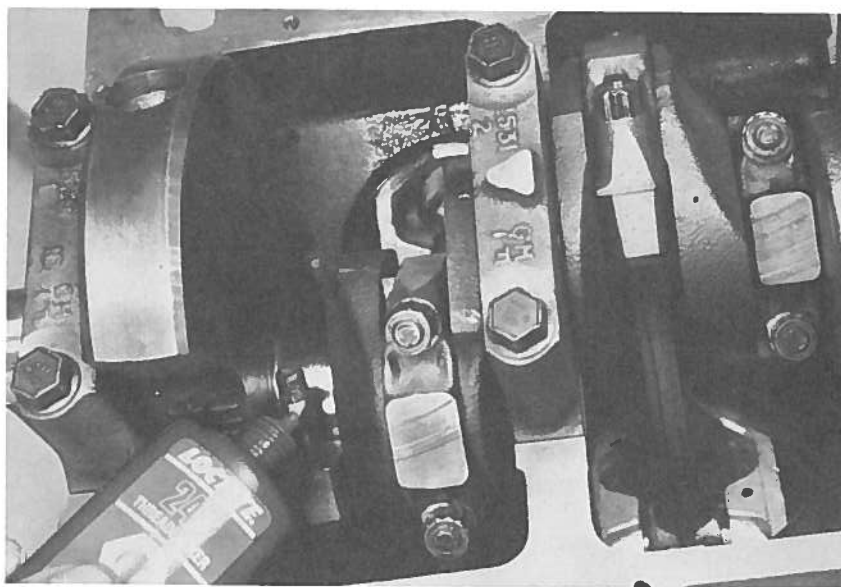
While holding the compressor tightly against the block, tap the piston into the cylinder, using a hammer handle. If the piston stops before it's fully in the bore,

stop tapping and find out what happened. Usually, a piston ring has popped out from under the ring compressor.

block, double check your work by measuring how much torque it takes to rotate the crankshaft. If more than about 15lb-ft is required, chances are something is wrong with the crank, rods, pistons, or bearings.

Oil Pump

The first thing you need to do with the oil pump is to install its driveshaft. Do this by slipping the retainer over the driveshaft on the pump and then pushing the notched



Although some would say this isn't necessary, a little extra insurance in the form of Loctite 242 Threadlocker can't hurt. Be sure to clean the threads of

both the bolts and nuts with brake cleaner before applying the threadlocker. The rod cap is off for purposes of illustration only.



A nylon retainer secures the oil pump drive shaft to the drive gear in the oil pump. Note that the proper end of the driveshaft to install into the retainer has a groove near its end.

end of the pump driveshaft into it. Gently tug on the driveshaft to make sure it is locked in place. This is an important check because if the driveshaft comes out, oil pressure will drop to zero and your engine will be moving on to that big melting pot in the sky.

Priming the Pump

Another important step during your rebuild is the priming of the oil pump. If the pump isn't primed, it won't pump oil through the engine, and all your hard work will go right out the window. I know, it seems silly that a pump sitting in a pan full of oil wouldn't pump any of the slick stuff, but it's true. If the inside of the pump is dry, the gears and pump cavity may not seal well enough to prime the pump. So you need to prime the pump in one of two ways.

One way is to submerge the pump in a can of clean engine oil, then rotate the driveshaft on the pump until oil flows out of the passage at the top of the oil pump neck. Another way is to pack the pump full of petroleum jelly. All cavities in the pump must be completely filled for it to prime. As the engine runs, the petroleum jelly liquefies and mixes with the engine oil.

After priming the pump, apply a light coat of non-hardening sealer, such as Permatex, to the pump flange on the bearing cap. Don't let the sealer slop down into the oil supply hole in the cap, or the engine may

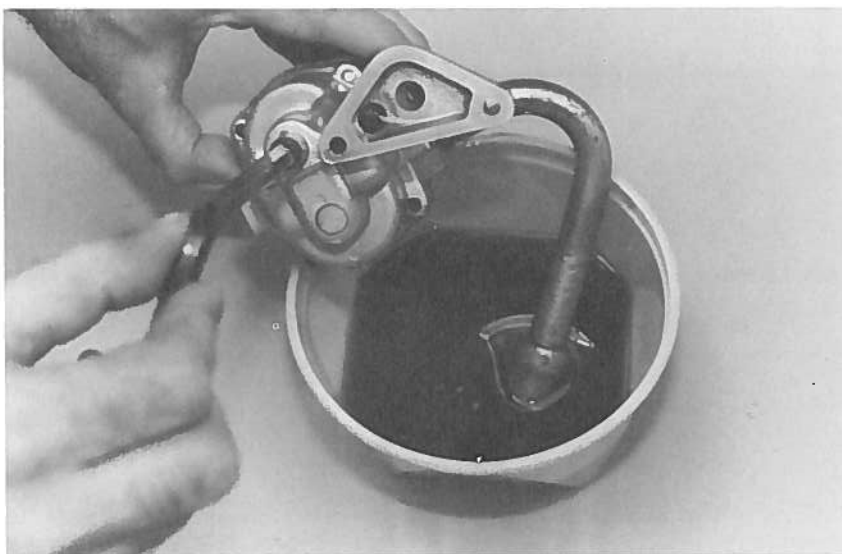
seize from a lack of lubrication. Now position the pump to the alignment dowels in the bearing cap and bolt it into position. Finish the job by applying some Loctite 242 to the threads of the pump bolt and then torquing the bolt to 30lb-ft.

Oil Pump Pickup Installation

Before installing the pickup into the pump cover, you need to determine where it has to be positioned, relative to the oil pan, to ensure the best supply of oil to the engine.

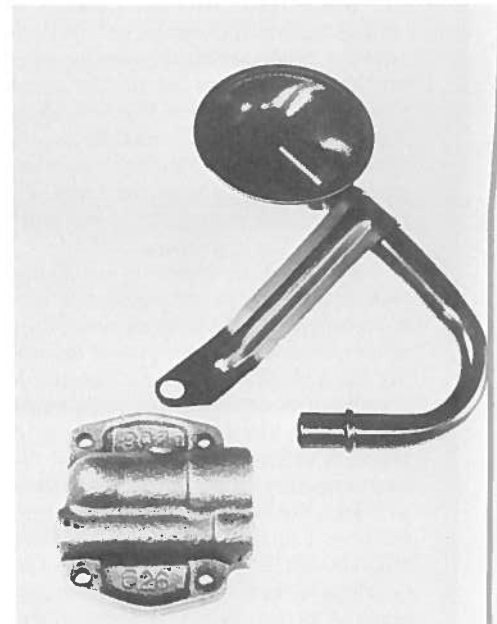
Clearance between the oil pump pickup and the bottom of the oil pan is critical to engine life. If it's too close, the pump will end up picking up the dirtiest oil from the bottom of the pan. Or it may even stop picking up oil at all, because it can't get between the pickup and the bottom of the pan fast enough. On the other hand, if the pickup is positioned too far away from the bottom of the pan, there may not be enough oil in the pan to meet the lubrication demands of the engine.

To determine where to position the pickup, place the gasket you're going to use for the rebuild on the flange of the oil pan. Then measure the distance from the top of the gasket to the bottom of the pan with a small square. Subtract 1/4in from this mea-

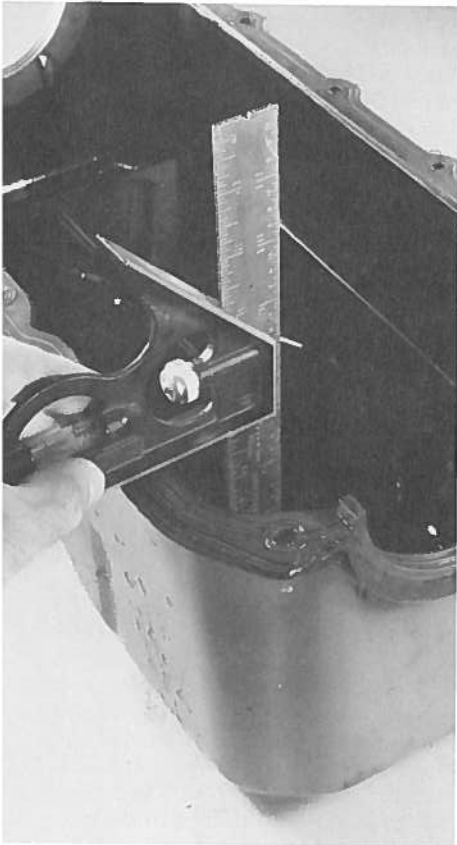


It's very important that you prime the oil pump, otherwise it may not draw the oil out of the oil pan. Submerging the

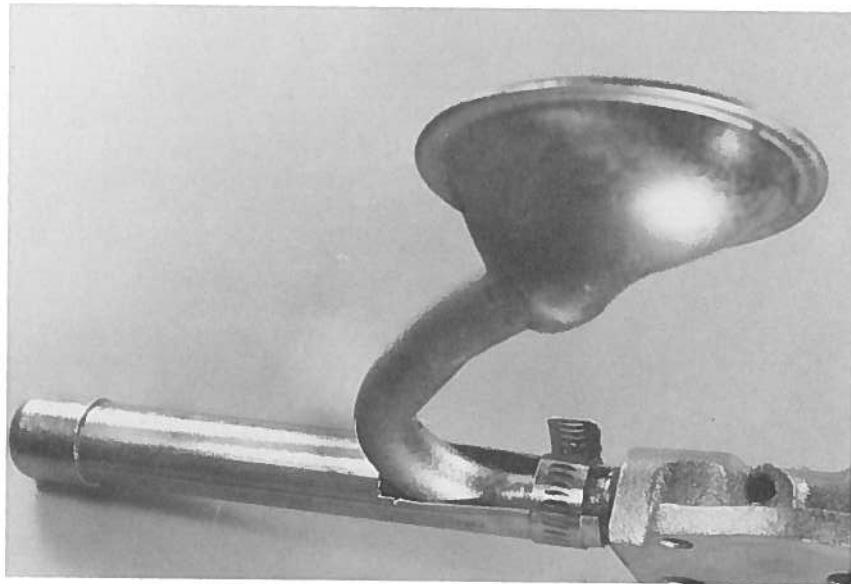
pump pickup in clean oil and rotating the drive shaft until oil flows out of the neck is one way of doing this.



Replacement oil pumps aren't available with the pickup installed. You'll need to adjust the height of the pickup for the particular oil pan and gasket combination you're using.



To get an accurate idea of where to position the oil pump pickup, measure from the bottom of the oil pan to the top of the oil pan gasket. Subtract 1/4in from this dimension, and that's where the pickup should be positioned.



A 6in length of 3/4in I.D. copper tubing can be used to fabricate a pickup installation tool. When secured to the pickup tube with two hose clamps, it al-

lows you to drive the pickup into the pump cover. Be sure to position the end of the tool against the flange on the tube.

that will be fitted into the pump cover. This is just a little "insurance" policy that the pump won't suck air instead of oil. Also remove the bolt on the pump cover that will be used to secure the pickup bracket.

With your homemade installation tool secured to the pickup, square the pickup tube to the hole in the

pump cover and tap the tool so that the pickup fits into the hole. Getting the tube started is the hardest part, so don't worry if the pickup height isn't where you need it to be, as long as it's in the ballpark. You're better off making the final adjustment after the pickup is installed.

Drive the pickup into the cover

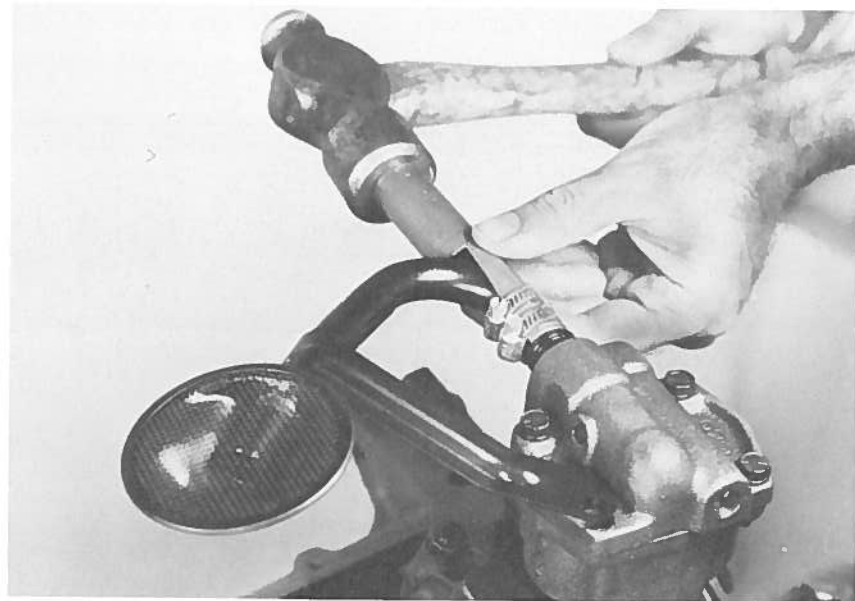
surement. This is where the lowest point of the pickup screen should be positioned.

If you position the pickup any lower than this, the chances of gunk in the bottom of the pan being sucked into the pickup increase. And if the pickup is any higher, the pump won't be able to access all the oil available in the pan.

To install the pickup without damaging its supply tube, you'll need to fabricate an installation tool. Copper tubing that's 3/4in in diameter and 6in long works well. With a hacksaw, cut a rectangular slot in one end of the tube that's large enough to fit over the pickup supply tube.

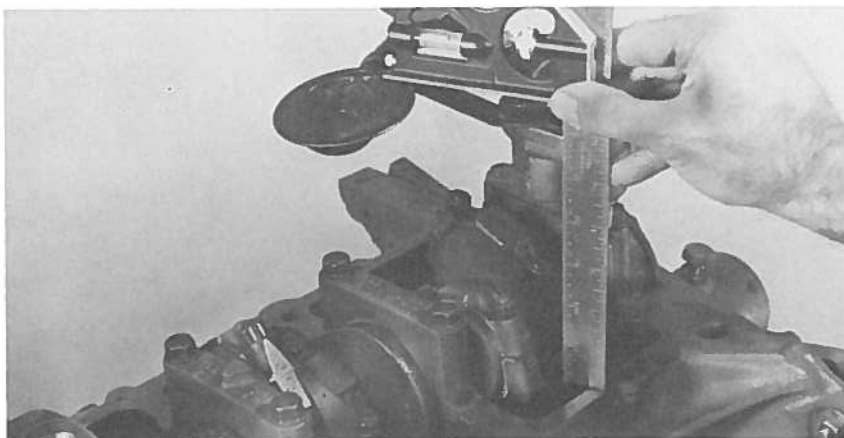
Slide your newly fabricated "tool" over the pickup tube so that it rests against the flange on the tube. Then use two worm-type hose clamps to secure the tool to the tube.

Now spread some non-hardening sealer over the end of the pickup tube



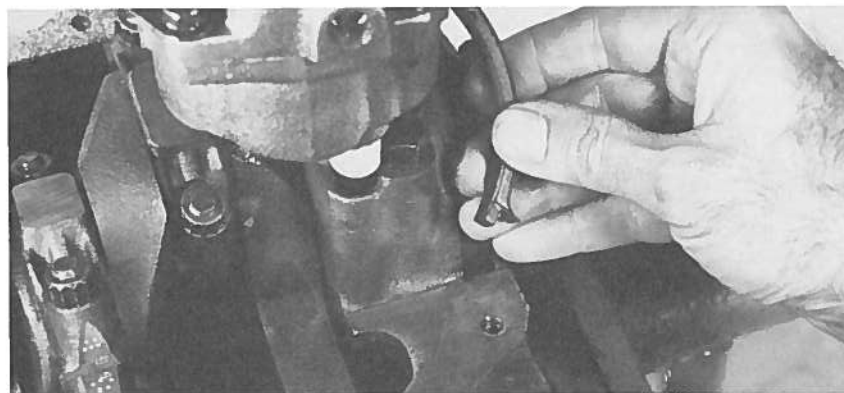
After spreading some non-hardening sealer over the end of the pickup tube, gently tap the pickup into the pump

cover. You can make fine adjustments to its height after the pickup is installed.



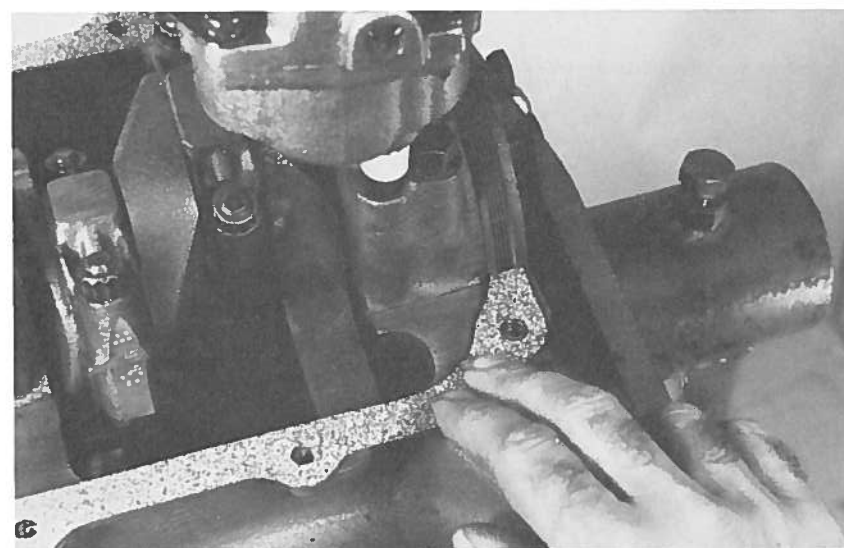
When the pickup is just about fully seated, check its height from the oil pan

rail. Adjust the pickup by tapping it with your hand until it's at the proper height.



The two-piece oil pan gasket used with earlier engines uses a separate rubber seal that fits into the rear main bearing

cap. Make sure its ends are fully seated in the block.



After matching up the holes in the side rail gasket with the bolt holes in the block, check the fit of the gasket to both

sides of the rear seal. If it rides up the seal, trim it with an X-acto knife so that it stops right at the base of the seal.

until the flare on the supply tube is within about 1/8in of the cover. Don't hit it too hard, or you can break the neck of the pump. When the pickup flange is close to the cover, wipe off any excess sealer from around it.

With the pickup height near its final position, hold the tube with one hand and bend the support bracket down to the oil pump cover with your other hand. Then check the height of the pickup one more time. Measure from the oil rail flange on the block to the intake side of the pickup.

If the pickup moved, readjust it, using your hand or a soft-faced hammer, and then check the bracket again. Keep doing this until the pickup height and bracket position are good. Then secure the bracket with the pump cover bolt you removed earlier.

If you're still not sure if the pickup is correctly located, check it with a strip of modeling clay. Lay a piece of wax paper over the pickup screen, and place a 3/8in thick piece of modeling clay over it. To prevent the clay from sticking to the pan, spread a thin coating of oil over it. Then carefully install the oil pan, with the gaskets you intend to use in position, while not disturbing the clay. Next, install the pan retaining bolts and tighten them down to specifications.

Now remove the bolts and carefully remove the pan. You should see a piece of clay that's been slightly compressed. Measure it at its thinnest point. If it's thinner than 3/16in, the pickup will be too close to the pan. Conversely, if the clay is thicker than 5/16in, the pickup will be too far away from the pan. Adjust the pickup as necessary to obtain the correct height.

After setting the pickup height, you need to make sure that the pickup won't move. If your pickup uses a bracket to secure it to the oil pump, be sure to use some threadlocker on the retaining bolt. If your pickup doesn't use a retaining bracket, you'll need some means of securing it to the cover. Otherwise, vibration may cause the pickup to fall out of the pump. The best way to do this is by MIG welding or brazing. Before you do this, just remember to remove the cover from the pump and the pressure regulator valve and spring from the cover to avoid heat damaging them. If you don't have access to welding or brazing equipment, stake the pickup to the cover with a punch or chisel.

Two-Piece Oil Pan Gasket

When the oil pump pickup height is set and the pump is primed, install the oil pan.

Two types of oil pan gaskets have been used on the 60deg V-6: a two-piece system consisting of a rubber end rail with a horseshoe-shaped cork composition gasket, and a one-piece rubber gasket.

If your engine is equipped with a two piece gasket, begin its installation by placing the rubber rear seal across the back of the rear bearing cap. Then tuck the ends of the seal into the space between the bearing cap and the block. The tabs near the ends of the seal should rest on the block.

Now place the side rail gaskets against the block so that the holes in the gaskets are centered with the threaded holes for the oil pan retaining bolts. Then check the fit of the side rail gaskets to the rear seal. You don't want the side rail gaskets running up onto the curved portion of the seal, as this will cause an oil leak. If the gaskets do run up the seal, carefully trim them with an X-acto knife so that they terminate where the curved portion of the seal meets the block. To help prevent an oil leak from the areas where the side rail gasket meets the rear seal, apply a small bead of RTV sealer to them.

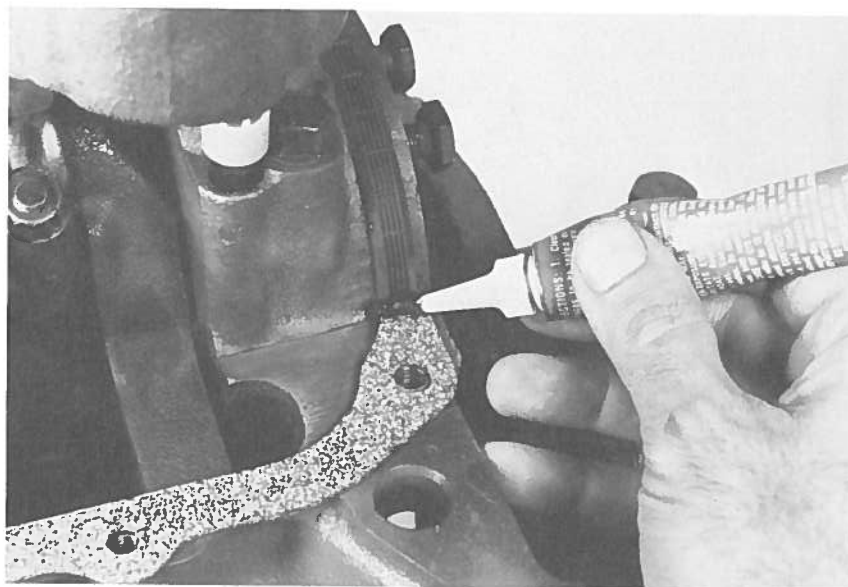
Complete the operation by installing the oil pan and retaining bolts. Torque the bolts to specifications, starting at the centermost bolts and winding your way out in a spiral pattern to the ends of the pan as you did for the cylinder heads. Torque the bolts in three passes to gradually equalize the clamping force of the pan against the gasket. This minimizes the chance of an oil leak.

One-Piece Oil Pan Gasket

Installation of the one-piece rubber gasket is very similar to that for the two-piece gasket. Just make sure that you push the tabs on the gasket in on the sides of the rear main bearing cap. Also put a generous dab of RTV sealer on the oil pan side of the gasket where the rear main bearing cap meets the block. Be sure to do this on both sides of the cap. This should eliminate any potential oil leaks from this area.

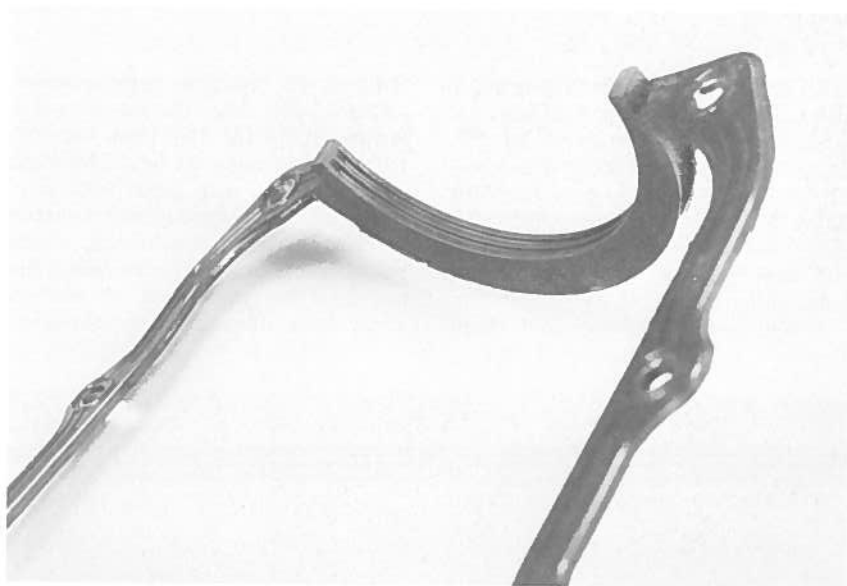
Camshaft

To install the cam into the engine without damaging its bearings you need some sort of "handle" for it. You



To prevent oil leakage, apply a small bead of RTV sealer to the joints be-

tween the side rail gasket and the rear seal.



The one-piece oil pan gasket has integral tabs where the gasket meets with the

rear main bearing cap. Make sure these are tucked in next to the bearing cap.



To prevent the cam from self-destructing in under an hour, coat the entire surface of each lobe with moly-lube paste (don't lube the first four lobes yet, as you will use them as a handle during in-

stallation). Don't use anything else, as moly-lube best stands up to the high unit loading of the lifters against the camshaft.

can install long bolts into the front of the cam (finger tight is sufficient) or simply bolt the cam sprocket on. Because the cam in the 60deg V-6 is relatively short, and the cam sprocket helps you hold the cam while you clean and lubricate it, I prefer to use the cam sprocket. Just install the bolts finger-tight.

With your handle secured, clean

the cam one last time, using a chlorinated solvent. After the solvent evaporates, lubricate the cam journals with EOS or assembly lube. However, don't coat the cam lobes with anything but moly-lube because it stands up best to the severe loading of the valvetrain on the cam lobes. All of the camshaft manufacturers, as well as some of the aftermarket suppliers, of-

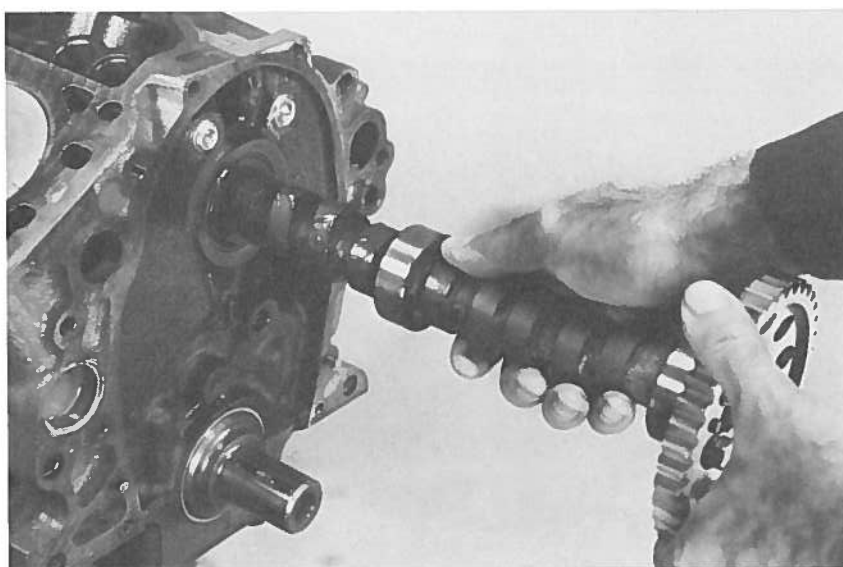
fer moly-based lubricants.

Use a clean finger or brush to spread the moly-lube over the entire surface of each lobe. However, don't lube the first four lobes on the cam just yet, as you'll be using them as a handle to help guide the cam into the block. If a mechanical fuel pump is mounted on your engine, spread some moly-lube over the more-rounded lobe at the front of the camshaft that drives the fuel pump pushrod, as well as the distributor and oil pump drive gear at the rear of the cam.

With the cam lubed, grab it by the first four cam lobes with one hand and by the cam sprocket with the other. Insert the cam into the block slowly, while watching its progress through the lifter bores. Use the cam sprocket for leverage to keep the rear of the cam from dropping during installation.

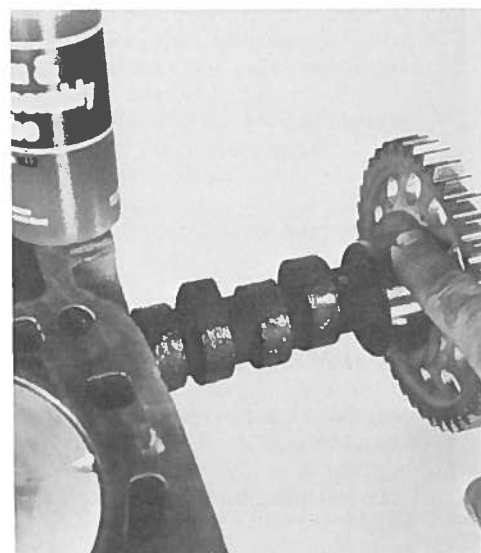
If the cam stops, its rear end has probably dropped or it's hanging up on the cam bearings. Whatever the situation, carefully guide the cam back into alignment with the cam bearing bores so as to not nick the cam bearings.

When the second cam journal is resting in the front cam bearing, lubricate the first four cam lobes with



With your hands positioned as shown, slowly slide the camshaft into the block.

Take care that you don't nick the cam or the cam bearings.



Before you install the cam completely, coat the unlubricated cam lobes with moly-lube. Also, wipe some assembly lube on the front cam journal and the thrust surface on the back of the cam sprocket. This will help prevent excessive wear until engine oil gets pumped to this area.

moly-lube. Wipe a little assembly lube on the front cam journal also, as well as the backside of the cam sprocket where it rides against the block. Then continue with the installation. When the camshaft sprocket is flush with the block, the cam is fully installed.

When the cam is in the block, make sure that it rotates freely by spinning it slowly with the sprocket. If the cam binds at any point, it's probably bent. If the binding is significant, the cam should be replaced.

If the cam rotates freely, rotate it one more time until the timing mark on the cam sprocket points exactly to the six o'clock position. This will make the installation of the timing chain easier.

Timing Gears, Chain, and Damper

Before you attempt to install the crankshaft sprocket, you need to install the woodruff key. On earlier engines, the key fits into the rectangular hole closest to the block. On later-model crankshafts, only one key is used.

Before installing the key, file off any mushroomed areas.

Install the key by gently tapping it into its hole with a brass drift. Take care not to mushroom its edges, and make sure it's completely bottomed in the hole. When it is, the hammer blows will feel "solid."

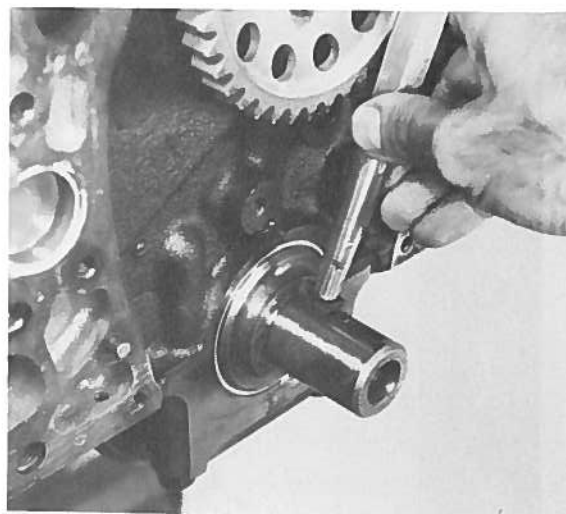
With the key bottomed out, lightly tap the front of it slightly downward. This will make it easier to install the crank sprocket, as will applying a light coating of clean engine oil on the nose of the crank. If your engine uses two woodruff keys, install the remaining key after you install the crankshaft sprocket. When the woodruff key is in place, take the crankshaft sprocket with its timing mark facing you, and slide it over the crank. Then align the keyway in the sprocket to the woodruff key.

To seat the sprocket, employ some 1-1/2in ID exhaust tubing. Make sure its ends are square so that it will push against the sprocket evenly. Then slide it over the nose of the crank onto the front of the sprocket. Now drive the sprocket on, using the side of a hammer. When the sprocket is fully seated, it will fit flush against the step on the front of the crankshaft. If you have trouble driving the sprocket on, make sure the woodruff key hasn't come out of position.

When the crank sprocket is fully seated, rotate the crank until the timing mark on the sprocket points directly to the twelve o'clock position and make sure the timing mark on the camshaft sprocket is pointed down to the six o'clock position. To ensure that the cam and crank sprockets aren't running dry when the engine first starts, lubricate their teeth with assembly lube.

Now, without rotating the camshaft, remove the cam sprocket and slip it into the timing chain. Then turn the sprocket so that its timing mark is facing you and points to the six o'clock position. Depending on the sprocket manufacturer, the timing mark can be a circle, triangle, or diamond near the outer edge of the sprocket. Now, while holding the timing chain with the sprocket and with the sprocket timing mark at six o'clock, hook the timing chain underneath the crank sprocket. Be sure the teeth of the sprocket are engaged in the chain. Next, carefully slip the sprocket over the front of the cam while sliding the locating dowel on the cam through the dowel hole in the sprocket. Then install the cam bolts finger-tight and check camshaft timing.

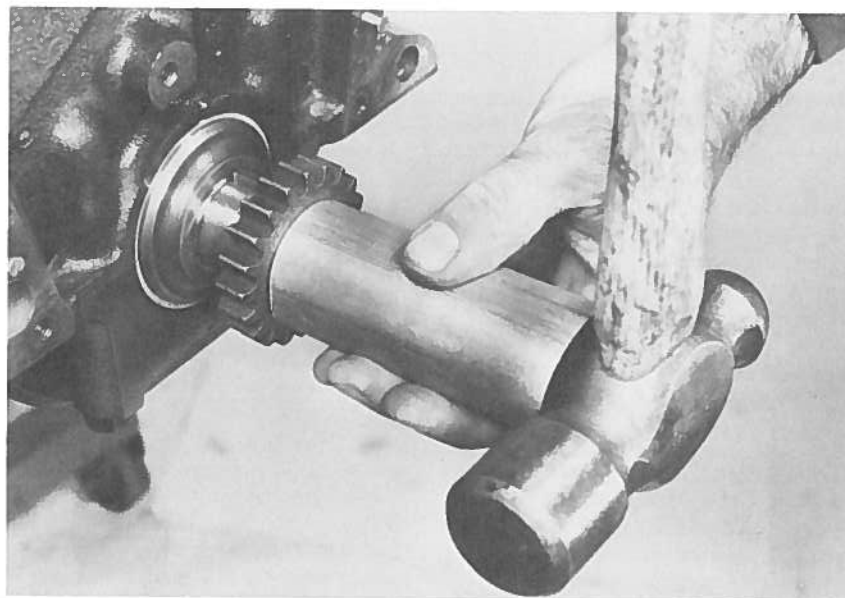
If the timing mark on the cam sprocket is still pointing exactly at the six o'clock position and the timing mark on the crank sprocket remains pointing at twelve o'clock, the cam is



To prevent the woodruff key from mushrooming, use a brass drift to seat it. This early-style crank uses two woodruff keys. Later-model cranks use one longer key to position both the crankshaft sprocket and the damper.

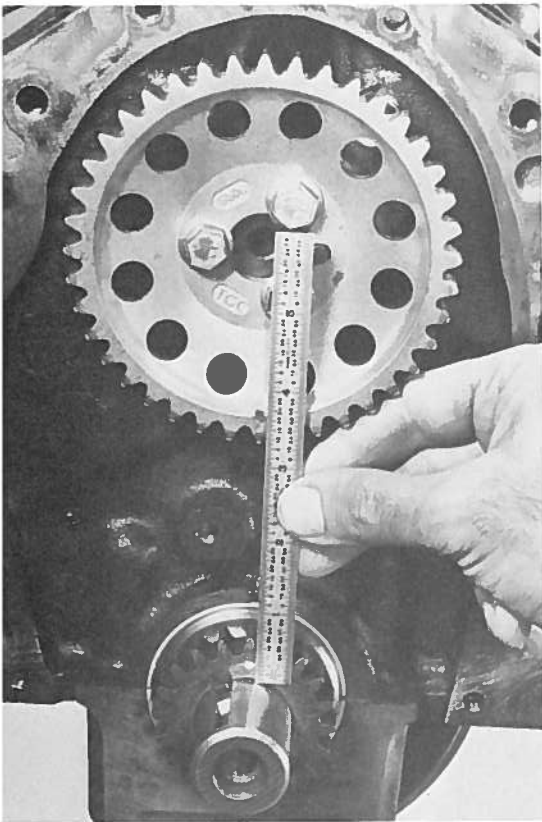
properly timed to the crankshaft. If it isn't, you'll have to remove the cam sprocket and reposition it so that the two timing marks line up. If the sprockets are off by just one tooth, the engine will run poorly, if it runs at all.

When you're confident that the timing marks are aligned, torque the cam sprocket retaining bolts to 18lb-ft. At this point, you can install the timing chain damper. Be sure that



Use a piece of exhaust tubing to seat the crank sprocket. Make sure that it's

fully seated against the front step in the crankshaft.

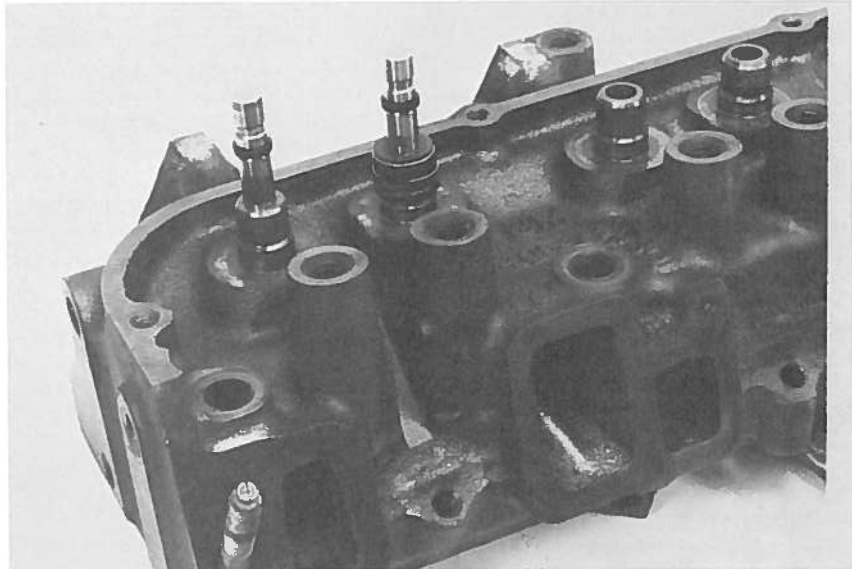


You can check the alignment of the camshaft and crankshaft timing marks with a straight edge. The sprockets need to be in this position when installing the timing chain. Check the alignment of the timing marks on the camshaft and crankshaft sprockets again after installing the chain, as they must be aligned for the engine to run properly.

the raised bosses around the bolt holes in the damper fit into the recesses around the bolt holes in the block. This registers the damper to the block. Then install the two retaining bolts and torque them to 15lb-ft. Finally, lubricate the chain with a light coating of assembly lube or clean engine oil.

Cylinder Heads

Due to ongoing engineering development, valve sealing in the 60deg V-6 has gone through several changes. Some engines use a seal on the top of the intake valve guide and O-ring seals at the top of both intake and exhaust valve stems. Other engines use only seals on top of both intake and exhaust valve guides. Still others use rotators on the exhaust valves while other engines do not.



This photo illustrates valve seal placement on a number of 60deg V-6s: O-rings near the top of each valve stem and a guide-mounted seal on the intake

valve. Later engines discarded the O-ring seal in favor of guide-mounted seals for both intake and exhaust valves.

Because of all these variations, it's easiest to follow the set-up your engine had before you started rebuilding it. For purposes of explanation, this discussion will cover the design that used an O-ring seal at the top of both valves and an O-ring seal on the top of the intake valve guide. This will allow you to install all the seals and hardware no matter what heads you're using. And remember, when selecting valve stem seals, be sure to specify that you want those made from Viton.

Valve Installation

Installing valves requires compressing the valve springs—springs that have the potential to injure you. So treat them with respect. Always stand to the side of the valve springs and avoid using your fingers to install the valve spring cap, valve stem seal, or valve stem locks. You should also wear a pair of safety glasses in case something gives way.

Inlet Valves

Make sure the valve is fitted to the guide it was removed from if you haven't had the valve guides serviced. If you're using new valves and/or have had the valve guides machined, it won't matter which valves you put in which guides as long as the exhaust valves go into the exhaust valve guides and the intake valves are fit-

ted into the intake valve guides.

Begin intake valve installation by lubricating the valve stem with assembly lube or EOS. Then slip it into the guide. Before installing the oil seal on the top of the valve guide, you need to slide the seal protector over the top of the valve stem. This little item looks like one-half of a medicine capsule and prevents the lips on the seals from catching in the grooves at the top of the valve stem.

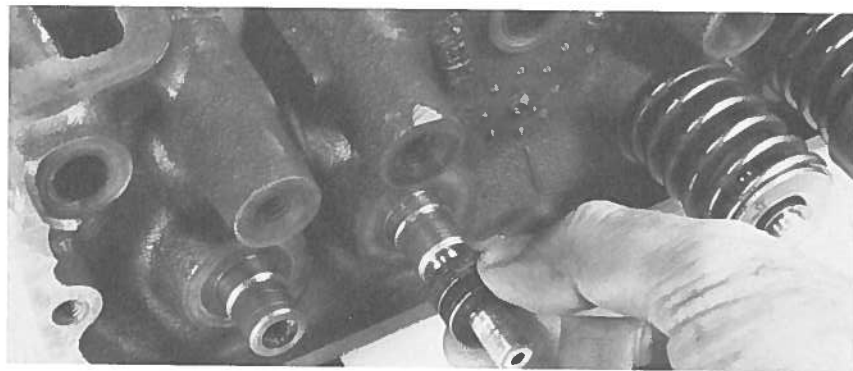
To ease seal installation, lubricate the exterior of the protector and the lips of the seal with assembly lube or EOS. However, don't lubricate the portion of the seal that slides over the guide or the top of the guide, because this increases the chances of the seal coming off during engine operation.

While holding the valve in its seat with one hand, slide the seal over the valve stem and onto the top of the valve guide. Use a 12mm deep-well socket to install the seal on the guide. Push the seal on with the socket, and rock the socket back-and-forth slightly until the seal bottoms out on the guide. When correctly installed, the sides of the seal should be parallel to the valve stem. If the seal is cocked, it isn't fully seated.

The next step is to install the spring damper over the valve guide seal. This makes it much easier to install the valve spring. Remove the damper from the valve spring by slid-



To prevent damaging the lips on guide-mounted valve stem seals as they pass over the reliefs on the valve stem, place a seal protector on the top of the stem. Lubricate the exterior of the protector to help facilitate seal installation.



After lightly lubricating the lips of the seal, slide it over the valve stem and onto the guide. Don't lubricate the top of the guide to make seal installation easier, because this increases the

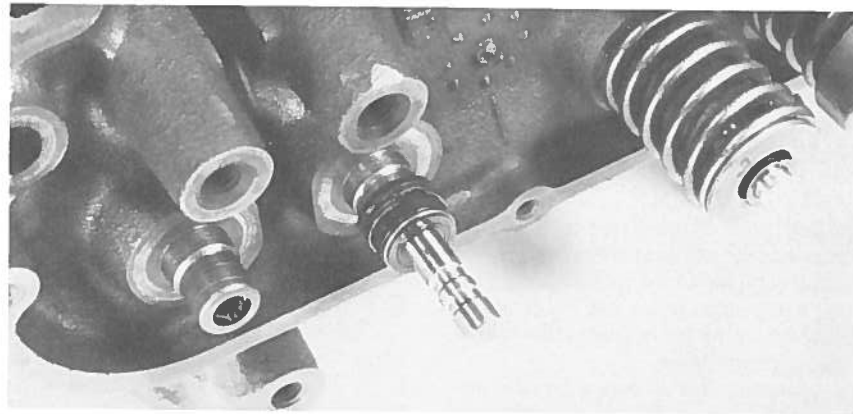
chances of the seal coming off the guide during engine operation. Use a 12mm deep well socket to help push the seal onto the guide. Make sure the seal is bottomed on the guide.

ing the tip of a screwdriver underneath one of the tangs on the damper and rotating it toward the slot in the damper. This will ease the tension of the damper against the spring, allowing you to remove it.

With the damper free, lubricate the inside edges of the tangs with assembly lube. This helps the damper slide over the valve stem seal. Then push the damper over the seal, and slide the spring over the damper.

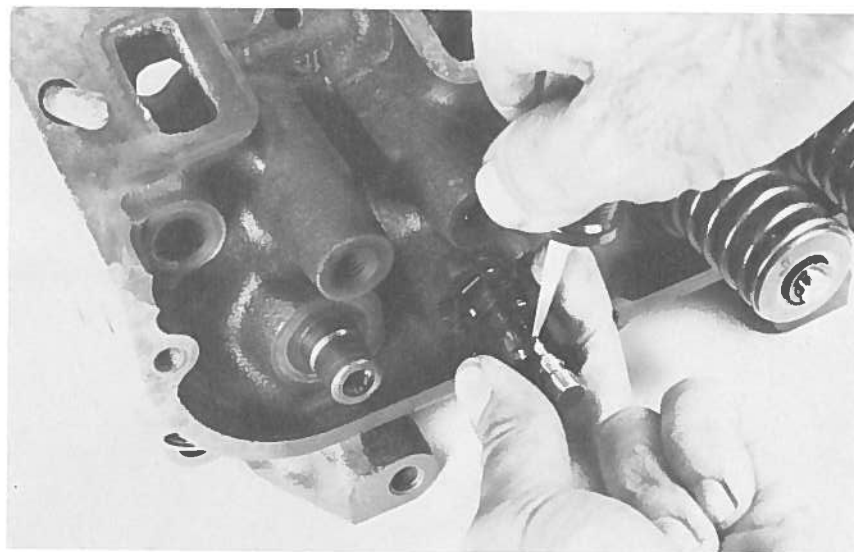
Now place the valve cap over the valve stem and onto the top of the valve spring. Position the fixed jaw of the valve spring compressor over the cap and center the compressor's moveable jaw over the head of the valve. If the ends of the fixed jaws tend to spread as the valve spring is compressed, secure them with locking pliers to prevent them from pulling apart. Compress the valve spring until the lowest groove in the valve stem is visible. If your engine requires O-ring-type valve stem seals, lubricate one now and slide it into the lowest groove, using a small, blunt instrument. Be sure the seal isn't twisted.

Before installing the valve stem locks, dip them in heavy wheel bearing grease. The grease will help hold the locks in place as you position them into the top groove of the valve stem. Be sure to use needle nose pliers to position them as this is safer than ex-



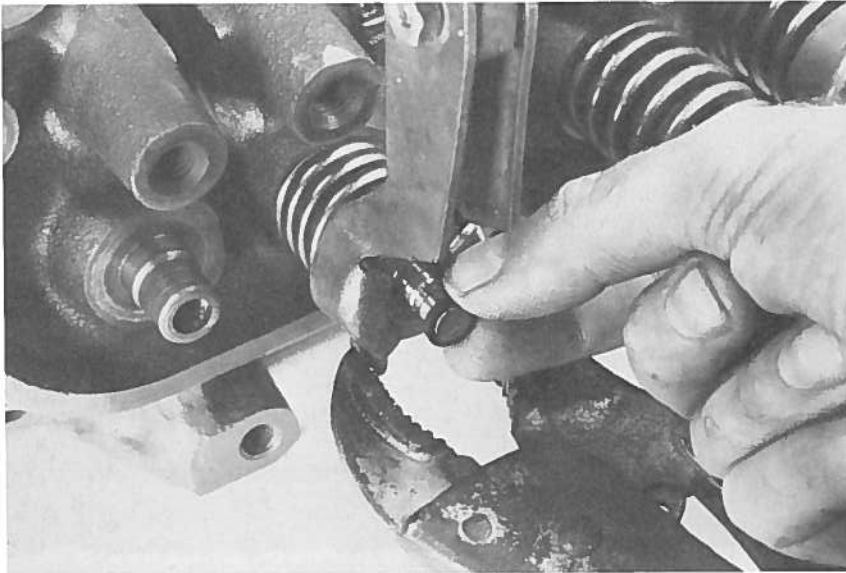
This is where the seal will be positioned when it's bottomed on the guide. Note

that its bottom edge does not fit down to the step on the guide.



Lubricate the inside of the damper tangs, twist the damper "open" slightly with a screwdriver, and slide the

damper over the seal. When the damper is seated, slide the valve spring over it.



After compressing the valve spring so that the lowest groove on the valve stem is visible, slide the O-ring onto the valve stem. Use an 8mm deep-well socket to push the seal into the lowest

valve stem groove. Make sure the seal isn't twisted when it's in position. Never use your fingers to position the seal, as you can injure yourself if the compressor lets go.

posing your fingers to the potential threat of the valve spring slipping out of the compressor. While making sure the valve stem locks don't slip out of position, slowly release the valve spring compressor.

Repeat this process for the remaining valves. If your engine is equipped with a splash shield on each exhaust valve, position the shield over

the spring before installing the valve spring cap or valve rotator.

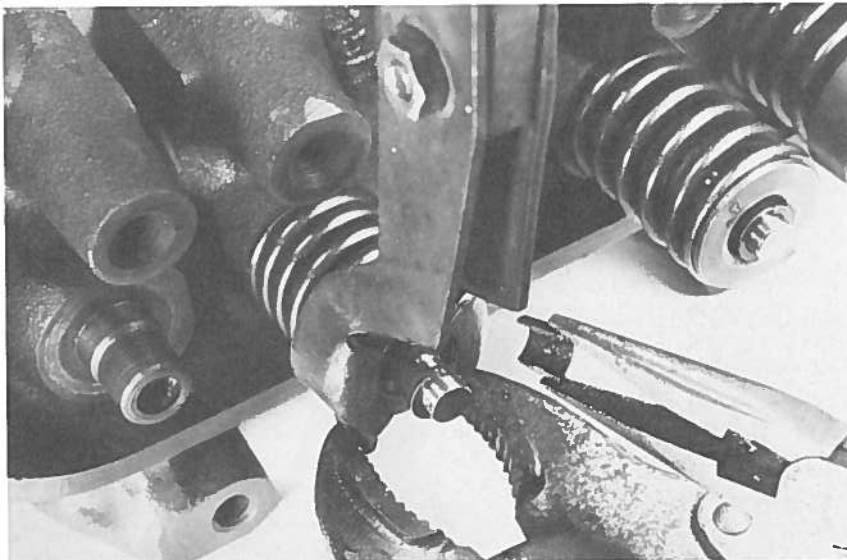
Cylinder Head Gasket

Before installing the cylinder head, check the orientation of all the holes in the new head gasket with those in the block. If some holes are of the wrong size or are missing, you may have the wrong gaskets. Remem-

ber, engines with Multi-Port Fuel Injection use head gaskets that are different than engines equipped with carburetors or throttle bodies. Pay particular attention to the way the gasket fits the cylinder bore. If it overhangs into the bore, you'll have a problem with preignition. So you'll need to find a better-fitting gasket.

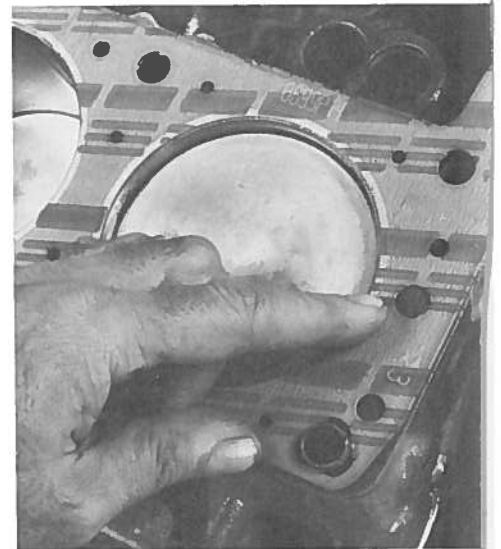
The cylinder head gaskets used on the 60deg V-6 are of the composition type—that is, they use a steel core sandwiched by a layer of sealing material. Some gaskets may also use beads of sealer around critical holes. Others may even be of the type where no retorquing of the gasket is necessary. Whatever the case, you need to remember that composition-type cylinder head gaskets should not be coated with sealer of any type, as it will ruin them. All that's necessary is to make sure the mating surfaces of the block and heads are clean. Then install the gaskets over the hollow dowels in the top of the block with the "TOP" or "UP" sides of the gaskets facing toward the cylinder heads.

With the head gaskets in place, install the heads on the block. Grab



After applying some heavy grease to the locks, use needle nose pliers to position them onto the top groove in the

valve stem. As you're releasing the compressor, keep an eye on the locks that they don't move out of position.



Make sure that the holes in each head gasket align with the holes in the block. Remember that some of the holes in the head gaskets (such as the two small holes between each cylinder bore) are designed to control the rate of coolant flow and should not be enlarged. Other holes simply aren't used. Install composition head gaskets without any sealer. Sealer will destroy the sealing properties of this type of head gasket.

the head by lacing your fingers into the intake and exhaust ports, and position it over the dowels in the block. The head will "sink" into position when it's properly located over the dowels.

Now apply some sealer, such as automotive pipe thread sealer or non-hardening Permatex, to the lower half of the threads on the head bolts. This will prevent coolant in the water jacket from seeping past the threads. When the bolt threads are coated with sealer, slide them through the head and screw them into the block. Remember, the shorter bolts are positioned on the outside of the head, near the exhaust ports. With the bolts finger-tight, torque them to specifications following the nearby illustrated sequence.

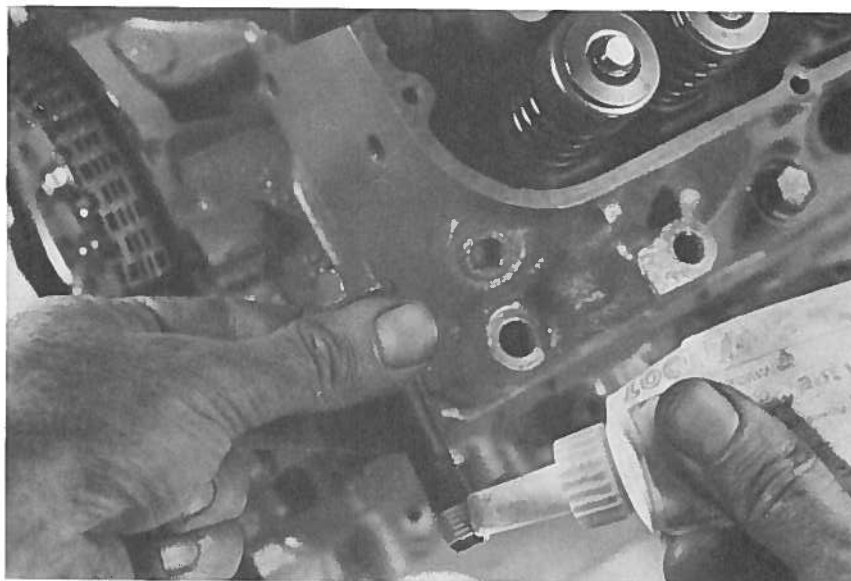
If your engine uses cast-iron heads, torque the bolts in three passes starting as 20lb-ft and finishing at 40lb-ft. For the last pass, note the position of the bolt head and turn it an additional 90deg (1/4 turn). This "torque-turn" method is the most accurate way to tighten fasteners.

The same, illustrated torquing sequence is used with aluminum heads, but only torque to 33lb-ft on the second pass. Again, finish up with an additional 90deg turn. If you apply a stripe of paint across the edge of the bolt head and the cylinder head, you'll be able to easily check how far you've rotated the bolt.

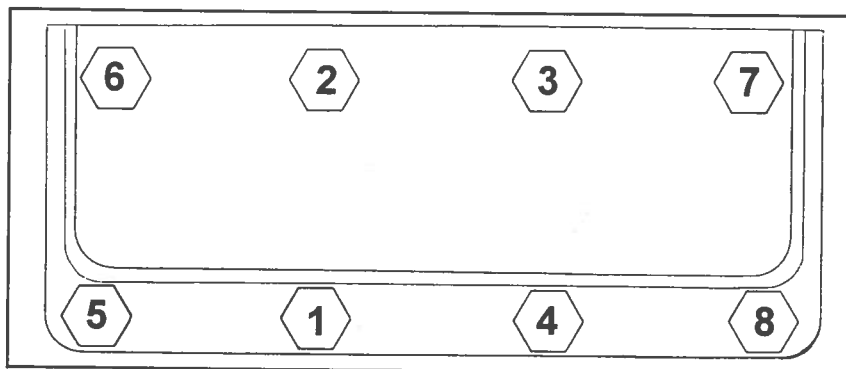
Lifters

You must prime the lifters to prevent them from pounding on the pushrods and cam the first time you start the engine after the rebuild. There are two ways to do this. If you have an oiling can, fill it with clean engine oil, and then direct its nozzle to the hole in the side of the lifter and pump oil into the lifter until it comes out of the top. Another way of priming the lifter is to submerge it in a can of clean engine oil, then pump the pushrod seat with a pushrod. Once the plunger stops moving, the lifter is primed. When the lifters are primed, keep them upright so that the oil doesn't drain out of them.

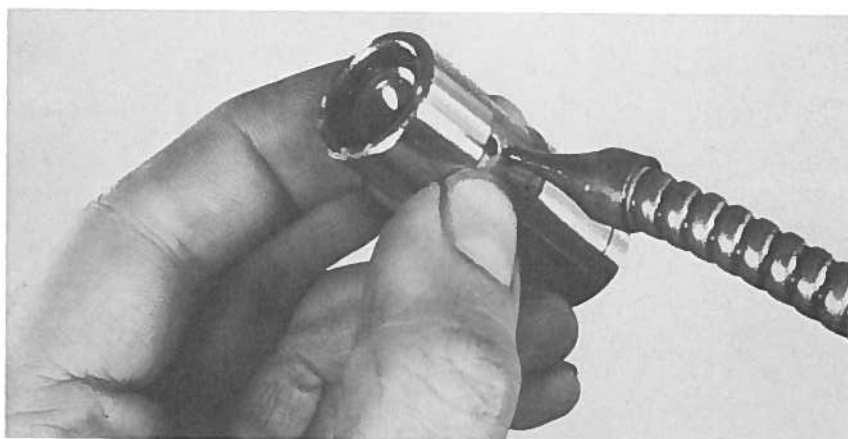
After priming the lifters, smear some moly-lube over their feet. This is essential to prevent rapid wear of the lifters and camshaft lobes. It's also a good idea to rub some EOS around the bodies of the lifters to prevent metal-to-metal contact when the engine is first started. As you lubricate



Apply non-hardening sealer to the threads of all the head bolts to prevent coolant leaks.

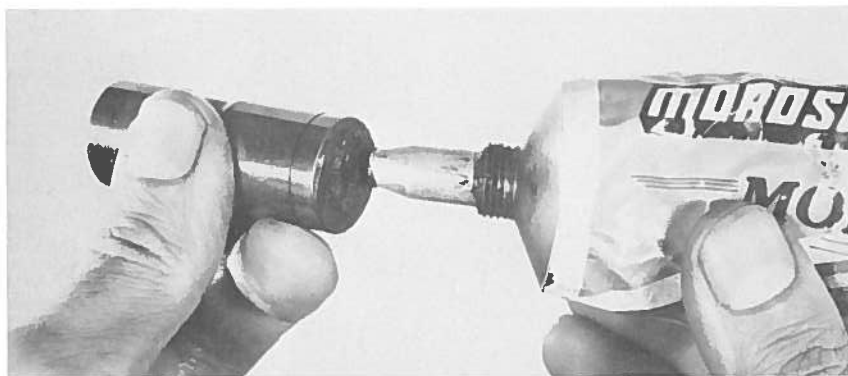


Torque head bolts following this sequence.



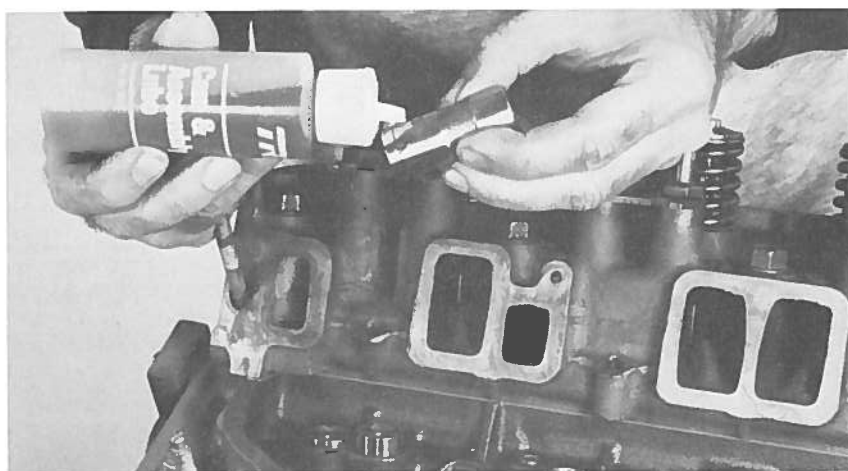
Lifters must be primed before installation. Put some clean engine oil in an oil can and prime each lifter through the

hole in its side. The lifter is primed when oil comes out of the pushrod seat at the top.



Apply moly-lube paste over the entire surface of all the lifter feet to help pre-

vent rapid wear of the lifters and the camshaft lobes.



Before sliding the lifters into the block, lightly lubricate their exteriors with assembly lube to fight scuffing.



To reduce wear on initial engine start-up, lubricate both ends of each rocker

arm, as well as the rocker ball seat and rocker ball, with moly-lube.

each lifter, slide it into the block. If you're using your old lifters on your old cam, be sure that you put them back into the same positions from which they were removed. If you're using new lifters on a new cam, it doesn't matter which lifter you put in which lifter bore. Also, if you have any oversize lifters, be sure to fit them to the proper bores.

Pushrods

Prepare the pushrods for installation by applying some assembly lube or EOS to the balls at their tops and bottoms. Also, smear a thin film of lubricant on the areas of the pushrods that ride against the guide plates in the cylinder head.

The next step is to install the pushrods. If you're installing them into an engine that uses splayed valves, remember that the pushrods for the intakes are shorter than the exhaust valves. And regardless of the type of heads the engine has, the push-rods need to go back from the positions from which they were taken—unless you're using new lifters and rocker arms. That's because these new parts don't have a wear pattern that could affect the durability of the pushrod balls.

To install each pushrod, insert one end of it into the seat in the lifter, then slide it into the forked opening in the guide plate. No particular end of the pushrod needs to point up or down.

Rocker Arms

With the rocker arms and balls clean, apply a thin coating of moly-lube to their wear surfaces. This includes the rounded section of the rocker ball and the rocker ball and pushrod seats in the rocker arm. Also lubricate the area on the rocker arm that contacts the valve stem. Now slide the rocker arms down over the studs. Be sure that each rocker arm is fitted to its original position and that the pushrods fit into their seats in the end of each rocker arm. Place the rocker ball over the stud and screw the rocker arm nuts down a turn or two. Don't tighten them down at this time, because they can cause valve-train damage since valve lash hasn't yet been adjusted.

Valve Lash Adjustment

There are two different methods for adjusting valve lash. The method used depends on the cylinder head de-

sign of the engine in question. If your engine uses cast-iron cylinder heads with valve stems that are parallel to each other, refer to the standard valves method. If your engine is outfitted with aluminum cylinder heads with valve stems angled away from each other, use the adjustment procedure for splayed valves. These methods are *not* interchangeable.

Standard Valves Method

To adjust the intake valves of cylinders #1, 5, and 6 and the exhaust valves of cylinders #1, 2, and 3, the piston in cylinder #1 must be at the top (TDC) of its compression stroke. Since the timing chain case hasn't yet been installed, the easy way to do this is to rotate the crankshaft until the timing mark on the camshaft sprocket is at the twelve o'clock position.

With the rocker arm for the intake valve of cylinder #1 loose, lightly take its pushrod between your thumb and forefinger and rotate it back and forth while you tighten the rocker arm nut. As soon as the pushrod stops rotating, stop tightening the rocker arm nut. This is called the "zero lash position." What's happened is that you've taken up all the slack between the pushrod and rocker arm. If you tighten the rocker arm nut any further, you'll be pushing the plunger inside the lifter down. What you need to do now is position the plunger to the midpoint of its travel. This allows engine oil to move the plunger higher or lower to take up any slack in the valvetrain that will occur as the engine runs. To put the plunger to its midpoint, tighten the rocker arm nut an additional one-and-a-half turns. Adjust the remaining five valves using these same techniques.

To adjust the intake valve lash of cylinders #2, 3, and 4 and the exhaust valve lash of cylinders #4, 5, and 6, you'll need to rotate the crankshaft once again so that the camshaft sprocket is pointing at the six o'clock position. Now you can adjust these valves using the same method that you used for the other valves.

Splayed Valves Method

For those of you "adjusting" the valve lash on splayed valve heads, the procedure is very simple. All you need to do is torque the rocker arm nuts to 18lb-ft. Doing this automatically adjusts the valves. Don't you wish life was this easy?



After the rocker arm is in position, slip the rocker ball over the stud. Then screw the retaining nut onto the stud.

Intake Manifold

Like all other V-type engines, intake manifold sealing on the 60deg V-6 is critical. If it isn't done correctly, you'll end up with a vacuum leak, oil leak, or coolant mixing with the oil. To avoid any unpleasantness, take your time installing the gaskets, sealer, and manifold.

The 60deg V-6 uses gaskets for sealing the sides of the manifold to

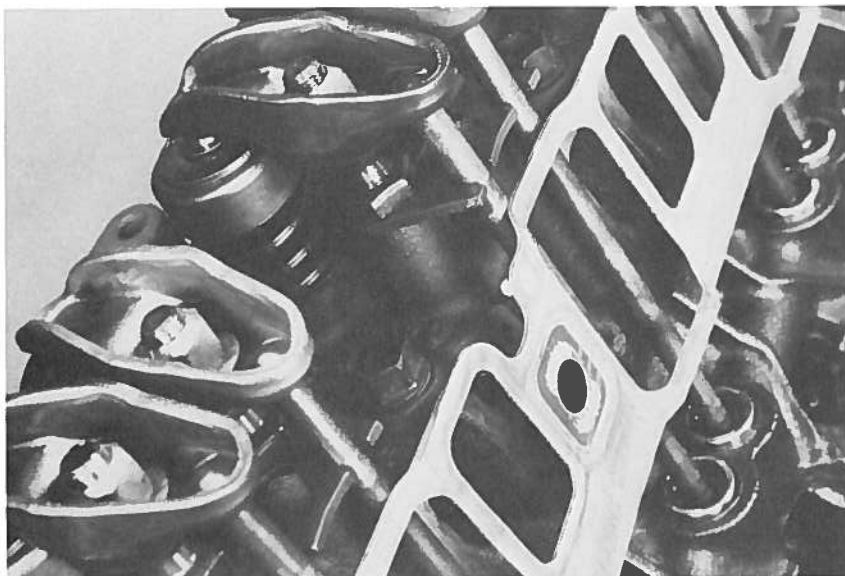
the heads, and RTV sealer at the front and back. As long as the sides of the intake manifold and their mating surfaces on the heads are clean of debris, you shouldn't have any sealing problems.

However, in addition to being free of debris, the front and rear sealing surfaces of the intake manifold and block need to be absolutely free of oil and grease. If they're not, the RTV



To adjust valve lash, gently roll the pushrod between your thumb and forefinger while you slowly tighten the

rocker arm nut. As soon as the pushrod slips between your fingers, tighten the nut another one-and-one-half turns.



This intake manifold gasket fits the left cylinder head, as evidenced by the small metal plate with the round hole. The barbed, white fastener above the

plate helps hold the gasket in position. This gasket won't fit against the head properly until it's trimmed to fit around the pushrods.

sealer won't stick to it. And if the RTV sealer doesn't stick, it will eventually move out of position, causing the problems noted above. Or it could get lost inside the engine, plugging an oil feed hole.

With this information foremost in your mind, begin assembly by identifying which gasket fits the left head and which fits the right. Not all en-

gines use a specific gasket for a certain side, but some do, so refer to the directions supplied with your gaskets for exact instructions. Also, look closely at each gasket. One side of it will be marked "TOP" or "UP." This is the embossed side of the gasket, and it must mate to the intake manifold.

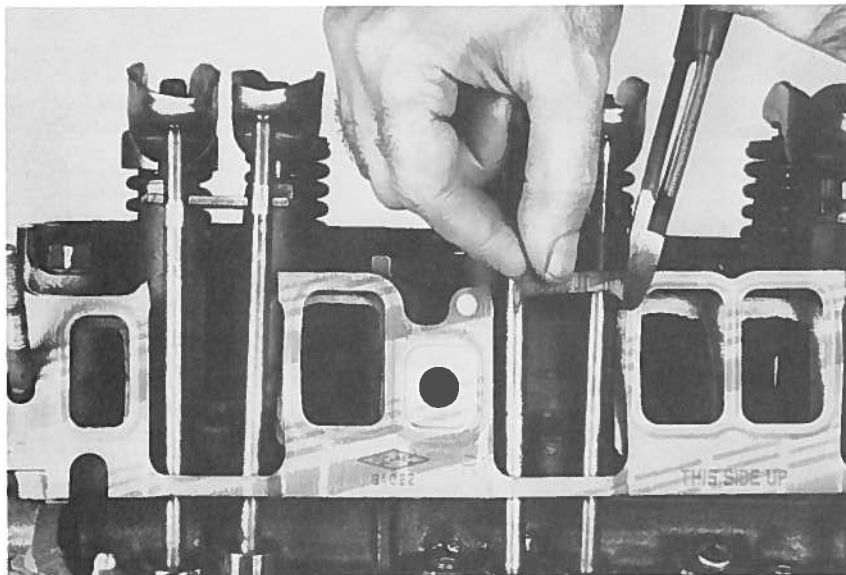
After you've identified the left and right gaskets, slide them over the

studs at the front and rear of the block. At this point, you'll find you can't situate the gaskets totally against the heads because the pushrods are in the way. So you need to cut out those areas on the gaskets that are touching the pushrods. But don't overdo it. Cut only the top bridging, not the bottom. The bottom bridging of the gaskets will clear the pushrods when the gaskets are installed against the heads.

When the gaskets are "modified," lay them against the heads. If any portion of the gaskets hangs into the ports in the heads, take a pencil and draw the correct shape on the gaskets. Then remove the gaskets and trim them as necessary. Sharp side cutters or an X-acto knife work well.

When the gaskets fit correctly, slide them down over the studs. Then secure them in position with the barbed nylon button near the top center of each gasket. These buttons fit into a corresponding hole in each cylinder head. Cast-iron heads have one hole each; aluminum heads have three holes each.

Now prepare the front and rear mating surfaces of the manifold and block by cleaning them with brake cleaner applied to a rag. You also need to clean the heads in the areas



Cut the upper "bridging" so that it clears the pushrods, but leave the lower bridging in place.



To ensure that the front and rear mating surfaces of the block and manifold are completely free of oil, clean them with brake cleaner on a rag. The RTV sealer won't stick if there's any oil on these surfaces. Clean under the lower tabs on each manifold gasket as well.

directly under the lower tabs at the front and rear of each manifold gasket. Make sure that these areas are absolutely free of any oily residue.

Now run a 3/16in bead of RTV sealer along the front and rear mating surfaces of the block, and up under the front and rear tabs of both intake manifold gaskets about 1/4in. This will help ensure a good seal. Work carefully to make sure that there are no breaks in the sealer, but don't take too long or the RTV sealer will begin to set. Whatever you do, don't use too much RTV sealer between the block and intake manifold, as it may be squeezed out from the joint and could end up circulating around the engine. Use only enough RTV sealer to do the job and no more.

With the sealing behind you, quickly place the intake manifold over the studs, making sure that it's facing in the proper direction. If the manifold cocks as it goes down on the studs, don't force it. Pull it up and start again. Finish the job by installing the bolts and nuts, then torquing them to specifications, following the accompanying illustration.

Timing Chain Case

Prepare the timing chain case by knocking out the old crankshaft seal. Work from the inside of the case out to remove the seal. With the seal removed, clean any old sealer or dirt out of the seal bore.

Before installing the new seal, apply a light coating of non-hardening sealer around its perimeter to prevent oil leakage. Then lay the case flat on your bench and place the edge of the seal in the bore. Make sure the seal is positioned so that its garter spring will be on the inside of the case.

To install the seal, place a short 2x4 over the seal and drive the seal into the case with a hammer. Work slowly so that you don't cock the seal. The seal is fully installed when it's within 1/16in or so of being flush with the cover.

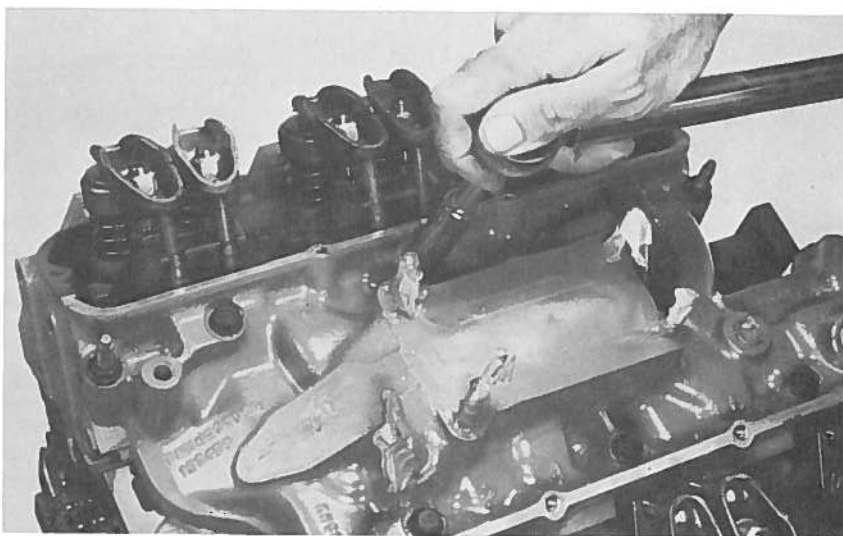
Installation of the timing chain case is next on the agenda. Prepare it by lubricating the lips of the crankshaft seal with clean engine oil. This minimizes the potential for damaging the seal when the damper is installed.

Now trial-fit the case gasket to the front of the block. Although it can be positioned either of two ways, only one is correct. When all the bolt holes and coolant passages line up, you have it right. Next, set the gasket

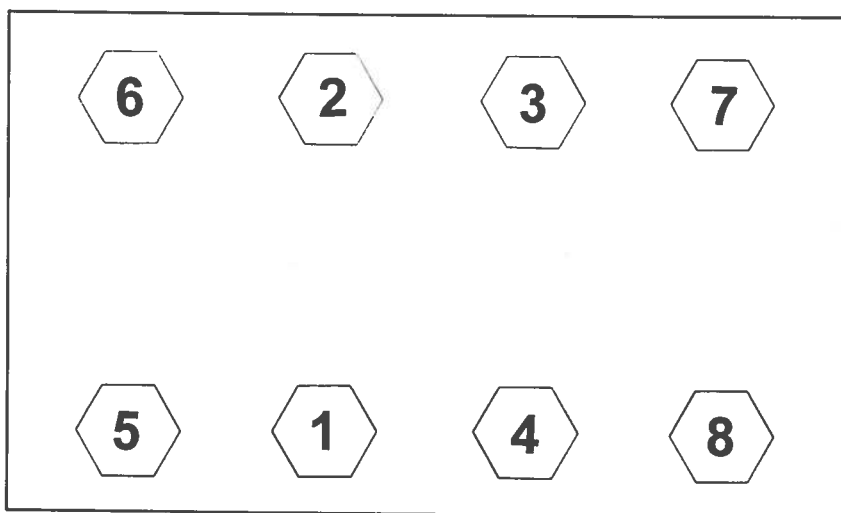


When you're applying the RTV sealer, run it up about 1/4in on each cylinder head (not shown in this photo). Have

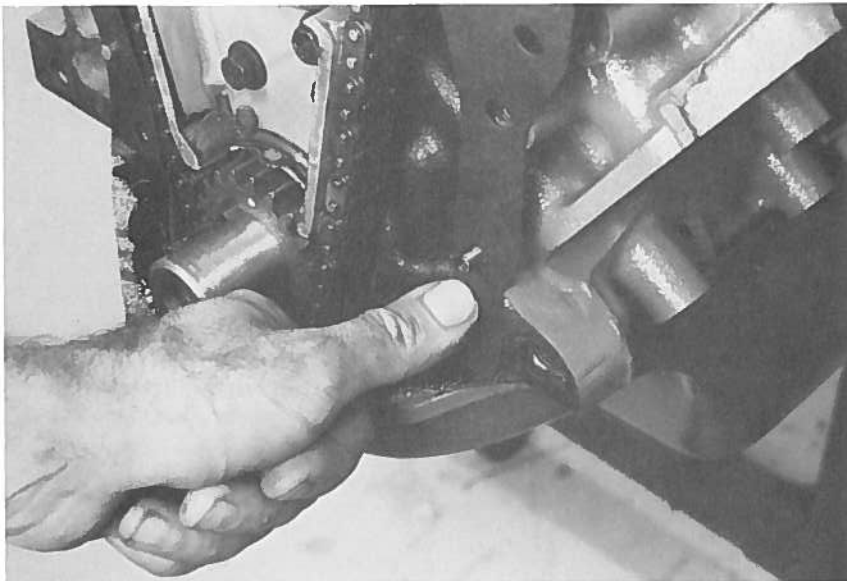
the manifold nearby so that you can install it immediately after applying the RTV sealer.



After placing the manifold on the engine, install the bolts and nuts and torque them to specifications.



Intake manifold bolt torquing sequence.



Before applying sealer to the block, slide the case gasket over the locating dowels so that you know how to position it after the sealer's been applied. To

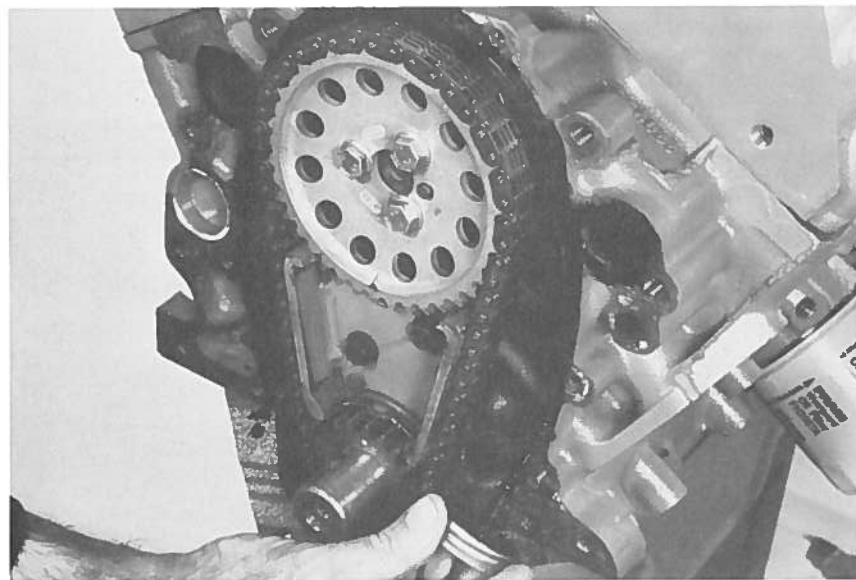
prevent an oil leak at the two joints where the block, oil pan, and case meet, apply a bead of weatherstrip adhesive.

aside and apply some non-hardening sealer, such as Permatex, to the gasket's mating surface on the block. Also apply some sealer to both sides of the front of the oil pan gasket if it's of the cork and rubber composition type.

To ensure that the joint between the oil pan, case, and bottom edge of

the block won't leak oil, apply a small bead of weatherstrip adhesive on each side of the block.

After the sealer's had 3-4min to set up, position the case gasket on the block, making sure it fits over the dowels. Then apply a thin film of sealer to the front of the case gasket.



You can use a brush-on non-hardening sealer on the block and case, or you can spray the gasket with sealer. If the area around the coolant ports in the

block (the two large holes on either side of the camshaft sprocket) are eroded, apply a thin coating of silicone sealer.

To make damper installation a little easier, apply a light coating of oil to the nose of the crank. Just don't let it slop down onto the oil pan seal. Now take the timing chain case and, while slipping it over the front of the crankshaft, align its locating holes with the dowels in the block. Then push the cover over the dowels so that it's nearly flush with the front of the block.

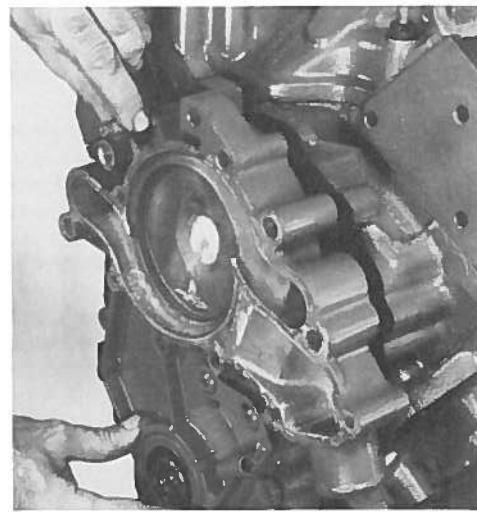
If you're having trouble aligning the locating holes with the dowels, don't try drawing the case onto the block with its bolts, because you'll probably crack it. Instead, pull the case off and check the condition of the locating holes and dowels. Small burrs on their ends could prevent the cover from mating to the block.

When the case is in its proper position on the block, install its retaining bolts and stud finger-tight. Then torque the stud to specifications. You need to do this now, because you won't be able to access it after you've installed the water pump. However, don't torque the other bolts until the water pump has been installed.

Finish the installation of the case by installing the bolts that secure the front of the oil pan to the bottom of the case. Install the bolts finger-tight, and torque them after you've torqued the water pump and case bolts.

Water Pump

For those of you who have engines with an integral water pump, now's the time to install it.



To get the case in position on the block, slide it over the locating dowels. This needs to be done by hand, not by drawing the case on with bolts.

Slide a couple of the water pump bolts through the pump and place the pump gasket over them. To protect against coolant leaks, swab some automotive pipe thread sealer over the threads of all the water pump bolts. Then position the water pump onto the front of the case and screw all the bolts in finger-tight. Torque them and the timing chain case bolts to the specifications shown in the accompanying illustration. Then torque the front-most bolts on the oil pan.

For those of you who have water pumps located to the side of the timing chain case, coat the bolt threads with automotive pipe thread sealer. Then slide them through the pump and hang the pump gasket on them. Next, place the pump into the case so that its locating dowel is in a vertical position, and install the pump bolts finger-tight. Finish up by tightening the bolts to 90lb-in.

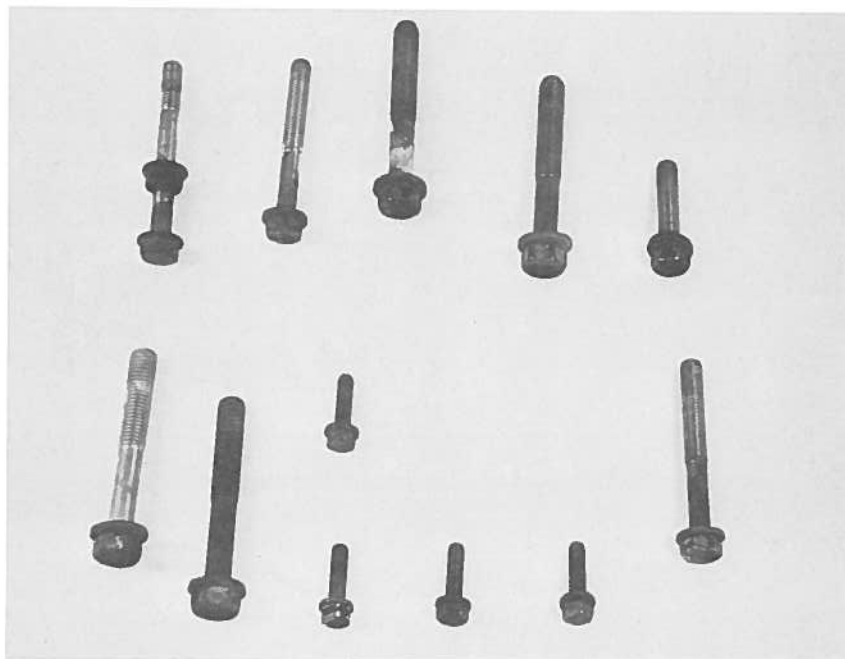
Damper

Installation of the damper must be performed with a tool that you can easily make at home with parts easily found at a hardware store. Whatever you do, don't try pounding the damper into place with a hammer, because you can destroy its tuning, ultimately causing the crankshaft to break. The installation tool consists of a 4in long M10x1.5 bolt and a thick, 1-1/2in-diameter washer that fits onto the bolt. You can use two or three thinner washers if you can't find a thick one.

Before you install the damper, lubricate its shaft (or repair sleeve) with engine oil so that it easily slides through the seal in the case. Also smear some oil inside the hub.

Now slide the damper onto the front of the crank while aligning its keyway with the woodruff key in the crank. Push the damper on as far as it will go. Then apply some moly-lube to the threads of your "installation tool" and screw it into the nose of the crank.

With the washer centered over the damper, tighten the bolt, all the while making sure the woodruff key isn't pushed out of position. The damper should slide on smoothly. If it doesn't, the key has probably moved. In this case, don't continue to draw the damper down with the bolt because you'll just destroy the threads in the crankshaft. Instead, remove the damper and reset the key as necessary.



This photo illustrates the positioning of the bolts if your engine is equipped with an integral water pump. Note the stud and nut at the upper left. The bolts start-

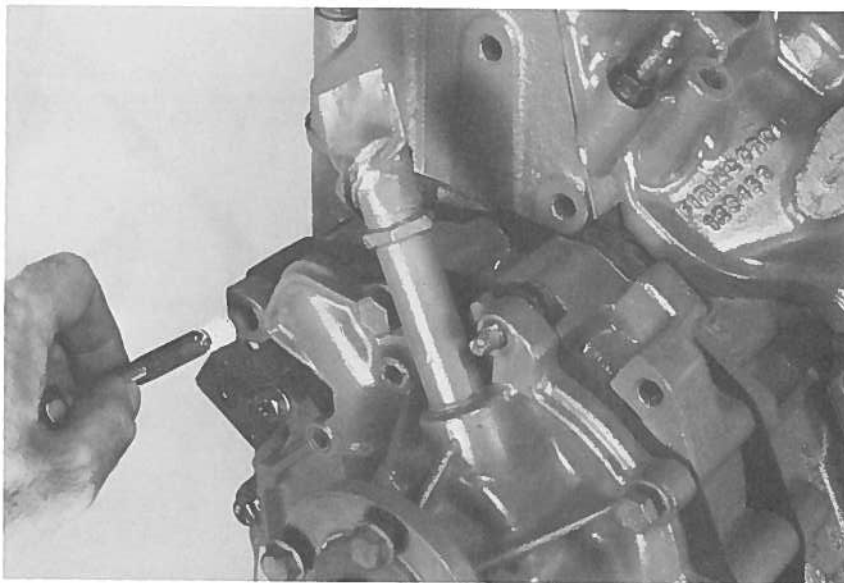
ing at the stud's right and winding clockwise are the proper bolts to use as you work in a clockwise direction away from the stud.

When the damper is drawn onto the crank as far as possible, remove the installation tool.

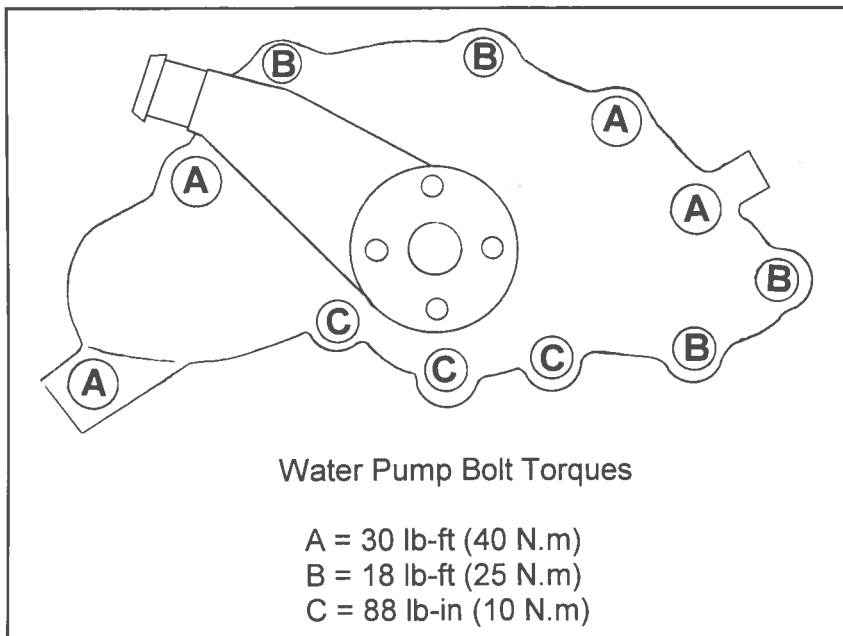
Crankshaft Pulley

Generally speaking, this is a good time to install the crankshaft pulley

because you can easily access the retaining bolts. This is especially true on some front-wheel-drive cars since the right-hand frame rail is so close to the front of the crankshaft that you may not be able to install the pulley when the engine is in the car. In cer-



Be sure to put some sealer on all of the water pump bolts before you install them.



Required torques for water pump bolts.

tain instances, however, you may want to wait to install the pulley, because it will give you more room to move the engine when mating it to the transmission.

To install the pulley, place it on the front of the damper so that its holes are aligned with the threaded holes in the damper. Screw the pulley and damper bolts in loosely at this

point. Wait to apply Loctite and torque them until after you've installed the flywheel. That way, you'll be able to hold the flywheel more easily, to keep the crankshaft from turning.

Rocker Arm Covers

When installing the rocker arm covers, remember that the cover with

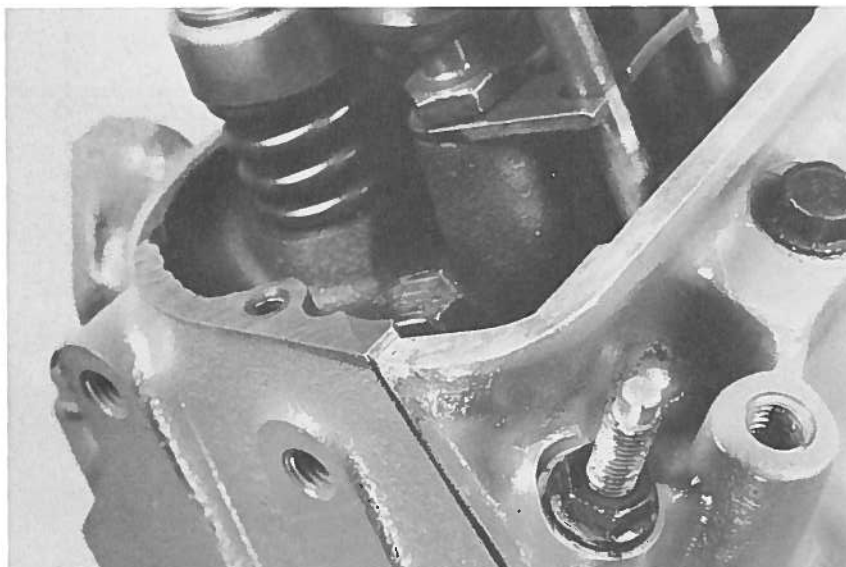
the oil fill cap is on the front cylinder head on front-wheel-drive cars or on the left cylinder head on rear-wheel-drive cars.

Begin by looking closely at the areas where the intake manifold meets the cylinder heads. For some reason, these areas always seem to be mismatched to one another. To minimize the chances for oil leakage from these areas, clean them with brake cleaner, and then apply a dollop of RTV sealer to each. Now place the gaskets into the rocker covers, and position the covers onto the heads. Install the cover retaining bolts, checking that the gaskets don't move as you tighten the bolts finger-tight.

Finally, torque the bolts to specifications, using an inch-pound torque wrench. Use of a torque wrench is the only way to ensure that you won't bend the covers and cause an oil leak. Torque the bolts in a circular pattern (starting with the innermost bolts) to the specifications listed at the rear of this book. You'll need to check their torque several times before you can be assured they're at the proper torque, due to the compressibility of the rocker cover gaskets.

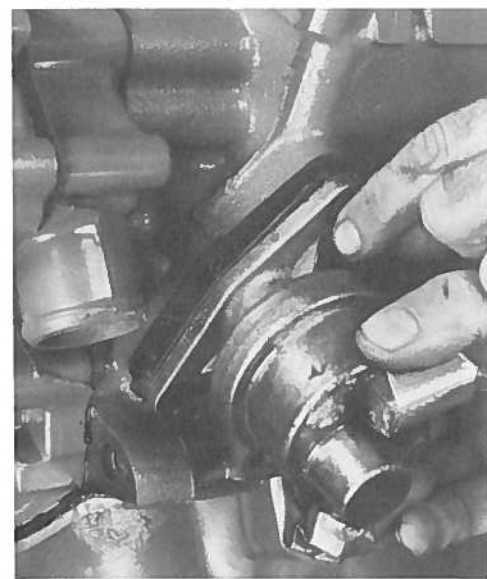
Fuel Pump

If your engine is equipped with an engine-mounted fuel pump, prepare to install it by having the pushrod, pump, and retaining bolts

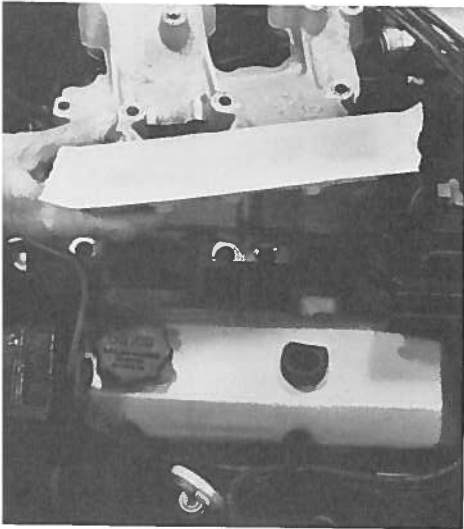


The joint between the intake manifold and the cylinder heads is usually mismatched. After cleaning these areas

with brake cleaner, apply a generous dab of RTV sealer to each.



Position the end of the fuel pump lever against the pushrod, and then quickly install the pump retaining bolts to prevent the pushrod from falling out.



Make sure the plenum gasket doesn't move as you install the lower plenum. The tape on the ports will prevent debris from falling directly into the engine.

next to you. You'll also need to slide the pump gasket into position on the pump.

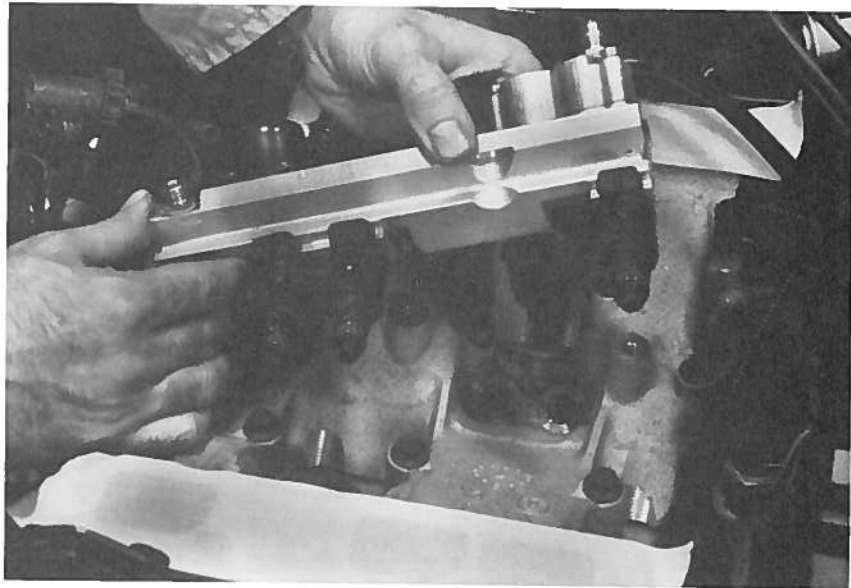
Install the pump by spreading some moly-lube over the ends and shaft of the pushrod, and then slide it into the block. While holding the pushrod with one hand, place the end of the fuel pump lever against it and push the pump into position against the block. Realign the gasket if necessary, then secure the pump with its retaining bolts.

Fuel System Multi-Port Fuel Injection

Begin installation of the MPFI system by positioning the lower plenum gasket onto the intake manifold. With the gasket in position, place the lower plenum over it. Then install the eight lower plenum bolts, and torque them to specification. As always, start with the innermost bolts and work in a spiral pattern to the outermost.

Installation of the one-piece and two-piece fuel rail assembly is virtually the same. First, lubricate the O-rings on the bottom of the injectors with clean engine oil. Then position the assembly over the lower plenum, with the fuel pressure regulator at the proper end of the engine.

Hold the rail so that the injectors are directly above the injector bores in the intake manifold, and then position them into the bores. Make sure the O-rings aren't pinched between



After lubricating the injector O-rings with clean engine oil, place the tip of each injector into its respective bore in

the manifold, then slowly push the rail into position.

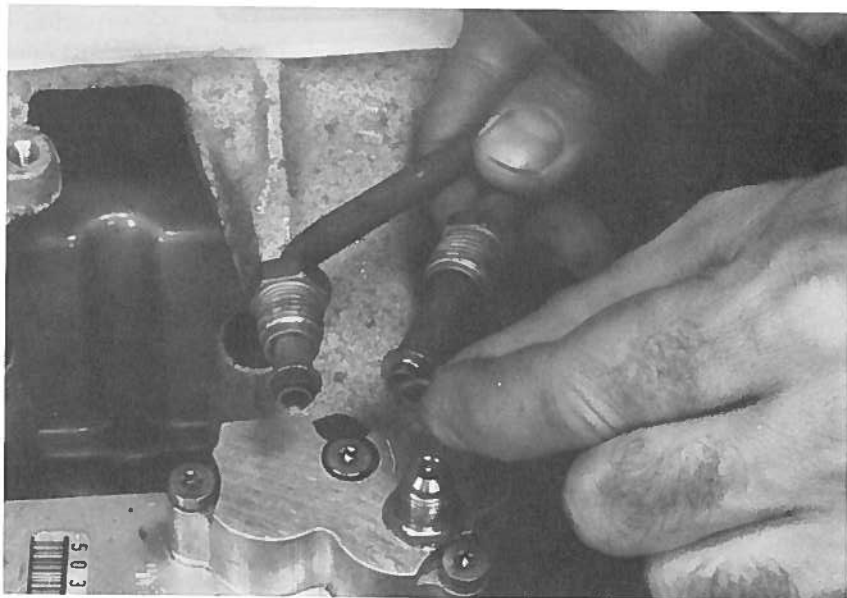
the injectors and the tops of the bores. When the injectors are piloted in the bores, push the rail down so that the injectors bottom out. Then install the rail retaining bolts, and torque them to specifications.

Next, connect the fuel lines to the rail. Be sure to use new O-rings on the end of each line.

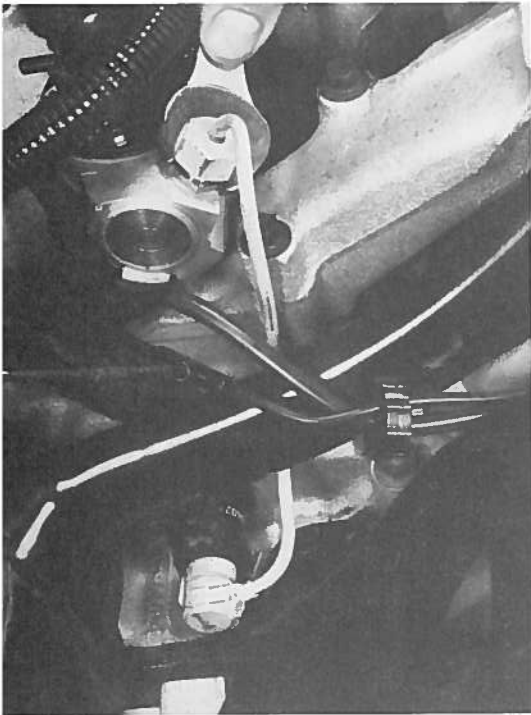
While making sure the O-rings

stay in position, start the fittings into the fuel rail by hand. Turn them in two or three turns, then tighten them securely with flare-nut wrenches. With the lines tightened, secure them with the clip located just downstream on the lines.

Next, reconnect the injector harness to the injectors. While making sure you've got the right connector for



Always use new O-rings on the fuel lines so you don't have a problem with fuel leakage.

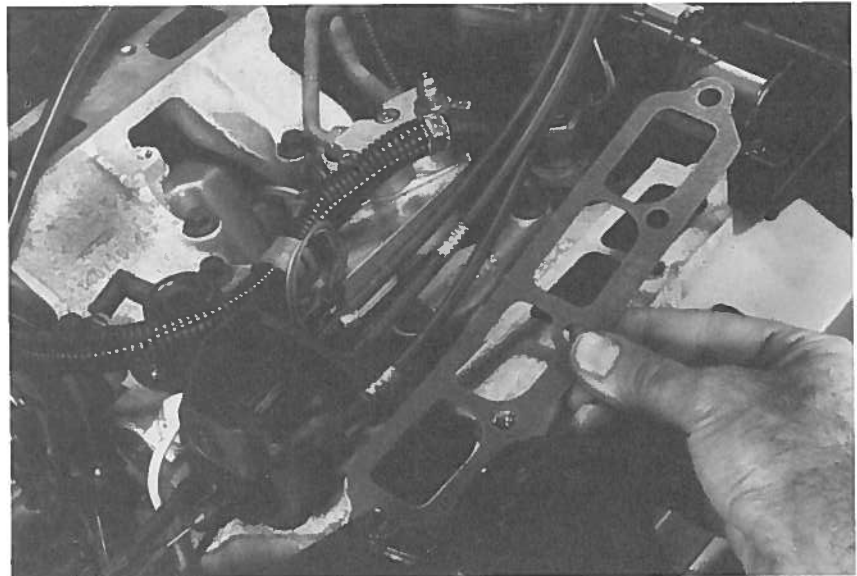


The cold start injector is positioned at the timing chain end of the engine on front-wheel-drive models and at the bell housing end of the engine on vehicles equipped with rear-wheel-drive. When the cold start injector is in position, tighten its supply line nut and mounting bolt.

the right injector, align the open slot on each connector over the tang on each injector and push the connector on. When you think the connector is fully seated, test it by gently tugging on it.

Before installing the cold start injector, fit a new O-ring on its end, as well as to the end of the fuel supply tube. After lubricating both O-rings with engine oil, loosely connect the supply line to the fuel rail. Then place the nose of the injector into the intake manifold and push it into position. After securing the injector with its retaining bolt, tighten the supply line nut on the rail and reconnect the vacuum line to the nipple on the fuel pressure regulator. Now lay the throttle cables down over the lower plenum and bolt their retaining bracket to it.

Moving along to the upper plenum, keep in mind that two different types of upper plenum gaskets were used, depending upon the design of the intake runners. So, before you install the upper plenum, trial-fit the gaskets to it and the lower plenum to



After removing the masking tape from the plenum, check that the gaskets you

selected are the right ones for the job. They should not hang over the ports.

make sure they fit. The gaskets shouldn't hang over into the ports and all the bolt holes should line up. If they don't fit, try flipping them over or switching them side-to-side. If this doesn't work, try the other set of gaskets that came in the gasket kit.

Before you install the upper plenum, connect the coolant hoses to the bottom of the throttle body. Use quality, worm-type clamps, and position them halfway between the end of the hose and the end of the nipple. With the hoses connected and the right gaskets in position on the lower plenum, carefully place the upper plenum over them and start the bolts in with your fingers. Afterward, tighten the bolts firmly with a wrench.

The next job is to install the air inlet hose. You need to work carefully here to ensure that the hose is completely sealed on both ends. Otherwise, some air will bypass the Mass Air Flow (MAF) sensor and cause a lean air/fuel mixture, to say nothing of the dust and grime that can enter the engine. When you're confident the hoses are in place, tighten the hose clamps firmly. Also, be sure to connect the small-diameter hose that runs from the air inlet hose to the PCV valve.

Now bring the convoluted tube from the EGR valve over to the side of the throttle body and bolt it to the throttle body, using a new gasket. Also reconnect the vacuum hose from

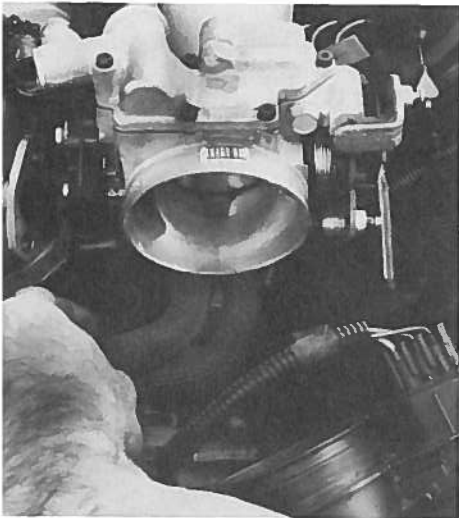
the power brake booster to the top of the intake manifold. If you forget this, the engine will have a lousy idle and brake pedal effort will increase five-fold.

Turning your attention to the electrical connectors, push them back in from where they came. When the connectors are fully seated, you'll hear their lock tabs snap back into position. Now push the rubber manifold with the three vacuum hoses attached to it into the top of the throttle body. Finish the job by connecting the various cables to the throttle body linkage. Make sure that they're secured by their retaining clips and that the throttle return springs are properly connected. Remember, they must pull the throttle completely closed.

Carburetor and Throttle Body

Installation of a carburetor and throttle body is very similar, the only differences between the two being the EFE grid underneath most carburetors and some electrical wiring and vacuum hoses. Therefore, we'll only discuss carburetor installation.

Install the carburetor by sliding a new base gasket over the studs in the manifold. The base gasket is integral with the EFE grid, so if your engine uses this, install it now. Then position the carburetor over the studs, screw the retaining nuts down over the studs, and tighten them securely. At this point, you can install the EGR



Remember to secure the coolant hoses to the nipples on the bottom of the throttle body. Protect against leaks by using new worm-type hose clamps.

valve and any sensors you may have removed from the intake manifold.

Exhaust Manifolds

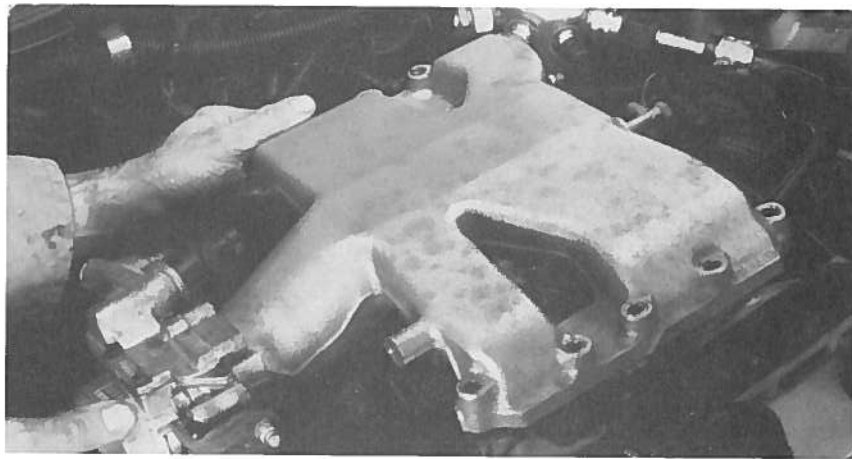
To make gasket installation easier, slip two manifold bolts through the lower front and rear bolt holes in the manifolds. Then position the manifolds to the heads and screw the bolts in about three full turns. Be sure the bolts engage the threads, or the exhaust manifolds will fall off.

Next, pull the manifolds away from the heads and slip the gaskets into place over the bolts. The steel side of the gaskets must face the exhaust manifolds. This allows the exhaust manifolds to slide on the gaskets as the manifolds expand and contract without damaging the gaskets.

If the engine is going into a rear-wheel-drive vehicle, install the remaining manifold bolts and torque them to specifications. Start at the center-most bolts, and work your way out to the ends in a spiral pattern. For front-wheel-drive vehicles, install the manifold bolts, but torque only the bolts for the rear manifold. The front manifold bolts need to be loose so that you can install the crossover pipe between the front and rear manifolds.

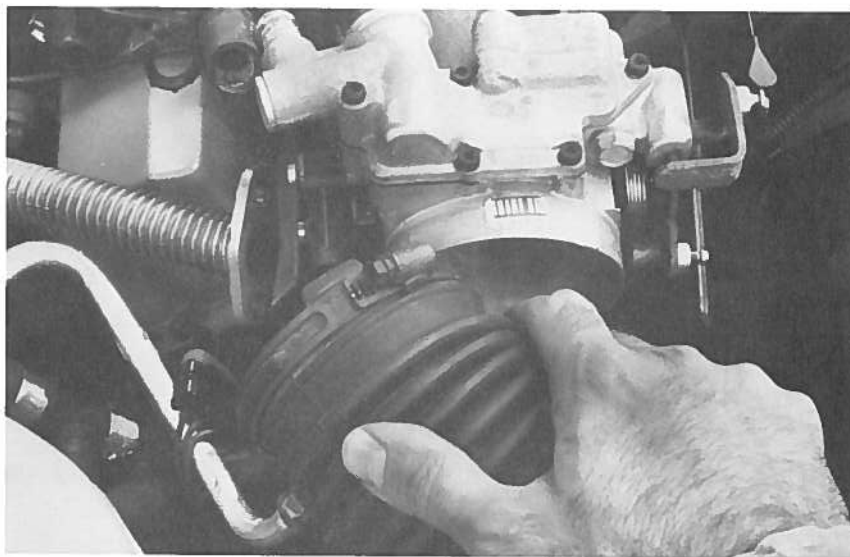
Spark Plugs

Before installing the spark plugs into aluminum heads, sparingly apply some moly-lube to their threads. The moly-lube will help prevent galling the threads in the cylinder heads.

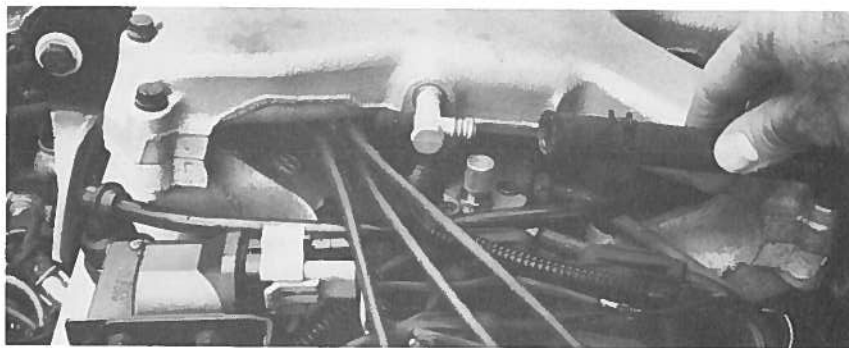


Lower the upper plenum onto the lower plenum, taking care that you don't push the gaskets out of position. Then install

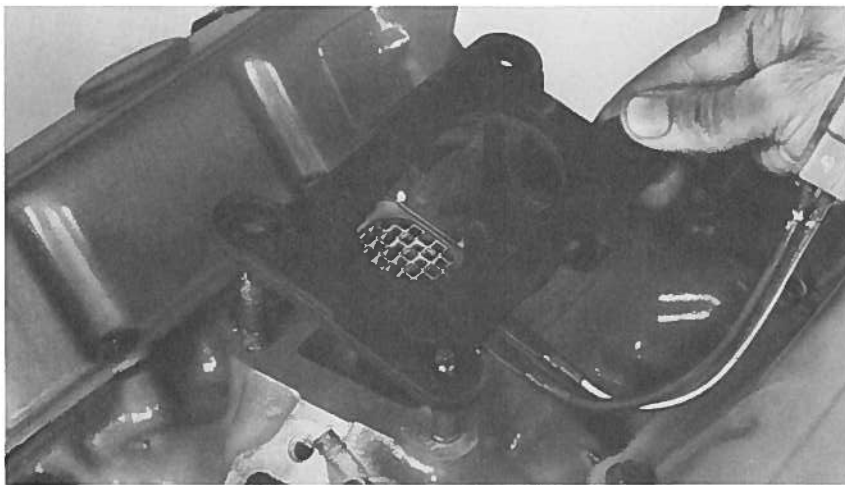
the bolts and torque them in a spiral pattern, working from the inner-most bolts outward.



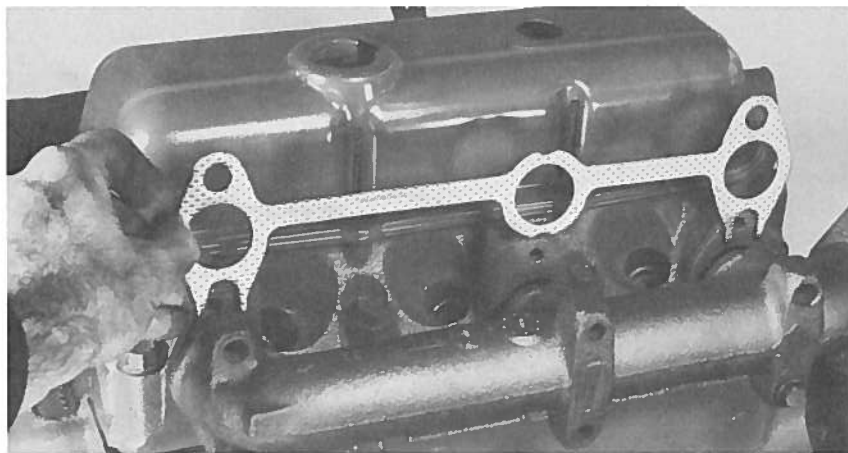
The air inlet hose must be properly sealed to the throttle body to prevent leaning out the air/fuel mixture.



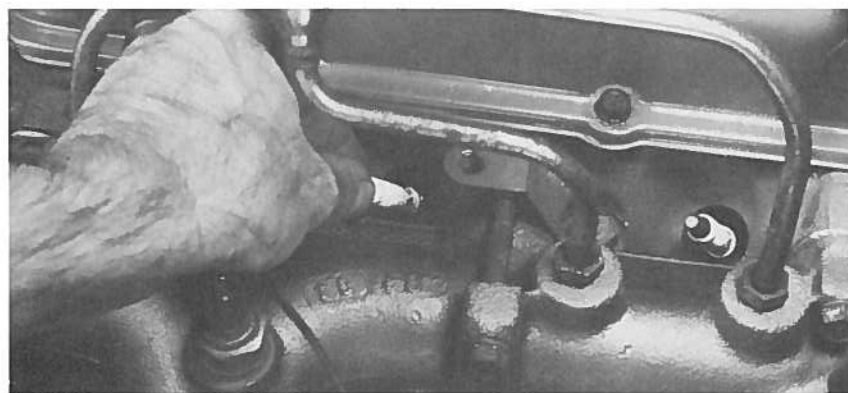
Connecting this hose to the upper plenum will ensure that your power brake system will work correctly.



Remember to place the base gasket and EFE grid into position before installing the carburetor.



With the steel-faced side of the manifold gasket facing outward, slip it into place over the lower manifold bolts.



Install the spark plugs at this point to prevent dirt from getting into the cylinders. If the plugs are going into aluminum heads, use a little moly-lube on

their threads to prevent galling. Note that the right-hand exhaust manifold has the AIR tubing installed.

Torque the spark plugs to the specification at the back of the book.

Priming the Lubrication System

Of all the work you've done thus far, the next job—priming the lubrication system—may be the most important. It's best to do this while the engine is on the stand, because if anything's wrong with the lubrication system, you can repair it with relative ease compared to when the engine is in the vehicle.

To prime the system, use a 5/16in socket on the end of a 6in long 1/4in drive extension bar. To prevent the socket from coming off the extension bar, clean both off with an oil-free solvent, then secure the socket to the extension with two or three wraps of duct tape.

When the "tool" is made, slip the socket over the end of the oil pump driveshaft. To help minimize the chances of oil being pumped out of the engine around the tool, slide your old distributor base gasket and two washers over the tool shaft. Start with the gasket, then install a 1-1/2in OD washer, followed by a 3/4in OD



After installing your priming tool onto the end of the oil pump driveshaft, use a large and a small washer to seal off the block. This will prevent oil from being pumped all over the back of the engine. The distributor hold-down clamp keeps the large washer in place while the small washer "floats" on top of it. The oil pump drive tool shown here was made using a cap screw welded to the end of an old oil pump drive shaft.

washer. Clamp the larger washer down, using the distributor or oil pump drive hold-down clamp. The smaller washer will just "float" on top of the larger one, allowing it to compensate for any side-to-side movement of your oil pump drive tool.

If the engine's for a rear-wheel-drive vehicle, install the oil filter adapter and gasket now. Make sure you use a new O-ring on the retaining bolt. After lubricating the O-ring with engine oil, install the bolt and tighten it securely. Now fill a new oil filter with about 8oz of fresh SH-rated 10W30 or 10W40 engine oil. Then apply a light coating of oil to the filter seal and screw the filter onto the engine or adapter.

Before you add the oil to the crankcase, first pour in a quart of EOS to ease component break-in. Then fill the crankcase with SH-rated engine oil to the "FULL" mark on the dipstick.

To monitor oil pressure, connect a mechanical oil pressure gauge to the boss just above and to the left of the oil filter boss on the block. Then position the gauge where you can easily read it as you drive the oil pump.

When the gauge is installed, chuck the oil pump drive tool into a 3/8in or larger drill motor. Start at a low rpm and watch the gauge carefully. Oil pressure may be non-existent for the first few revolutions as the oil begins to flow through the engine and oil filter. In a short time, however, it should rise to 30-40psi when you've got the trigger on the drill pegged, depending upon the speed of the drill and the ambient temperature. If oil pressure is building, the drill motor will begin to labor.

If you don't get any oil pressure, make sure the socket on your drive tool is engaged to the oil pump driveshaft. If everything's okay here, look closely at the line to the oil pressure gauge. When you're driving the pump, the oil in the line should move. If it moves but the needle on the gauge doesn't, the gauge is probably dead. However, if the oil in the line doesn't move, something's wrong with the oil pump, the bearing clearances are too large, or you've forgotten to install one or more of the threaded plugs in the camshaft gallery feed holes.

When the pump is running, have someone slowly rotate the crankshaft a couple of turns as this helps ensure complete lubrication of the engine.



Use a mechanical gauge to check oil pressure, as it's the most dependable

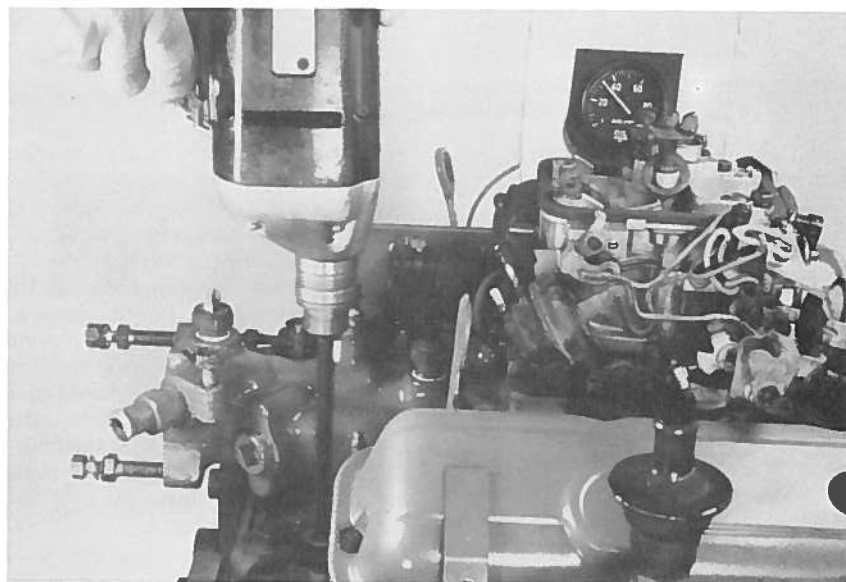
type of gauge. Tap it into the hole just above the oil filter boss.

Distributor and Oil Pump Drive

All of the 60deg V-6 engines manufactured through 1993 use either a distributor or, in place of the distributor, an oil pump drive. Since an oil pump drive is basically the bottom half of a distributor, and the installation of the distributor is more complex, we'll begin with distributor installation. Once you know how to install a distributor, installing an oil pump drive will be a snap.

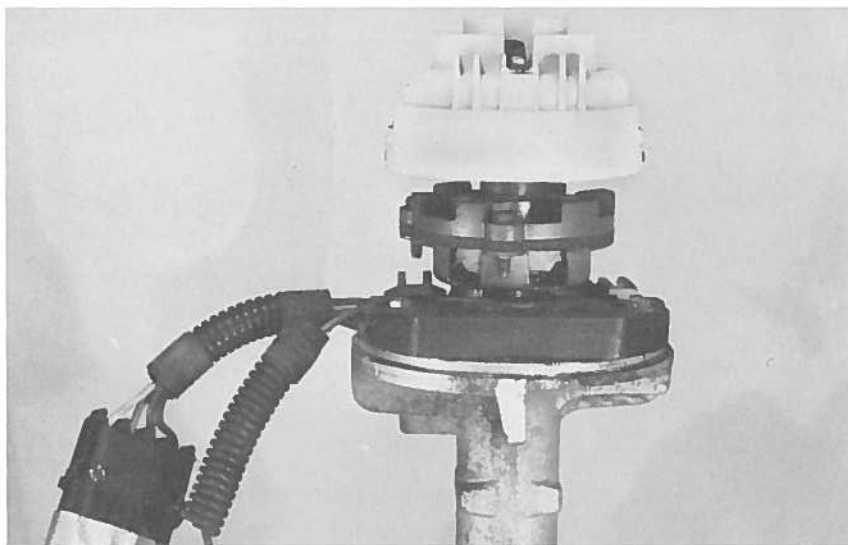
To successfully install the distributor, three things need to be done simultaneously: the end of the distributor must be mated with the oil pump driveshaft, the distributor drive gear must be engaged with the gear at the back of the cam, and the distributor rotor must be positioned to the firing position for cylinder #1 when the distributor is fully seated in the block.

Begin by rotating the crankshaft so that the piston in cylinder #1 is at the top of its compression stroke. This



As oil pressure begins to build, the drill motor will begin to labor. If oil pressure

doesn't build after 15sec or so, try reversing the direction of the drill motor.



Using the distributor cap, mark the base of the distributor where the terminal for cylinder #1 would be (identified by the white mark on the base). Then position

the rotor about 30deg before this mark. This will put you in the ballpark for ignition timing when you install the distributor.

means you'll need to align the timing mark on the damper with the zero mark on the timing tab. To ensure that cylinder #1 is indeed at the top of its compression stroke, place a finger over its spark plug hole while you rotate the crankshaft to align the timing marks. If you feel air pressure against your finger as the damper timing mark nears the timing tab, you'll know the piston in cylinder #1 will be at the proper position.

Now you need to identify when the rotor is pointing directly at the spark plug tower in the distributor cap. To do this, temporarily install the distributor cap, and mark the base of the distributor where the terminal for cylinder #1 is located. Then rotate the distributor shaft so that the rotor is positioned about 30deg before this mark when viewed from above.

While holding the rotor in this position, slip a new gasket over the bottom of the distributor and slide the distributor into the block. You'll feel the distributor slide into the block in steps. This is the end of the distributor engaging the oil pump driveshaft and the gear on the distributor mating with the gear on the cam. And that completes two of your three objectives. However, the distributor may not be fully seated against the intake manifold.

To get the distributor to drop against the manifold, rotate the dis-

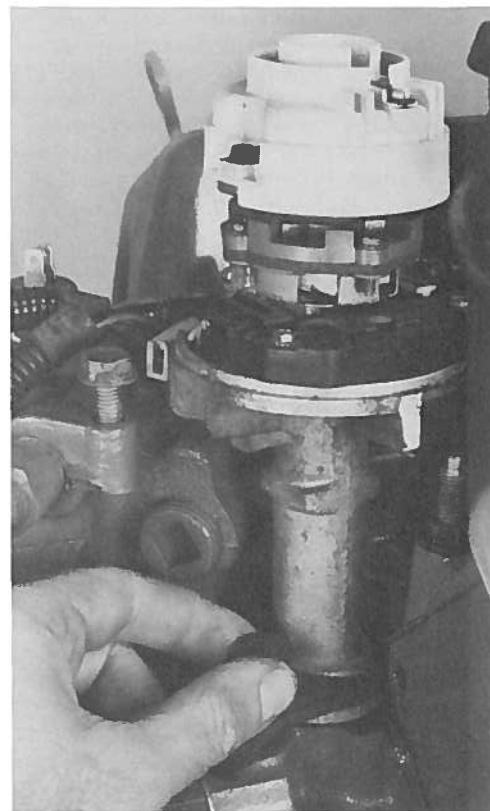
tributor base and the rotor back and forth slightly. The distributor should drop. When it does, check the alignment of the rotor with the mark on the distributor base that identifies cylinder #1. If it's within 15deg or so either way, you can just rotate the distributor housing to make up the difference. However, if the rotor is more than 15deg away from the mark for cylinder #1, you'll need to remove the distributor and reinstall it. The reason that the rotor moves when you install the distributor is that the helical drive gear on the distributor spins the distributor shaft when it mates with the gear on the camshaft.

When the distributor is set, install the hold-down clamp. Tighten the clamp just tightly enough so that it takes a little effort to rotate the distributor by hand. This will allow you to adjust the ignition timing as needed after starting the engine.

Oil pump drive installation is very similar to distributor installation, but it doesn't require alignment of any timing marks. All you need to do is slide the drive into the block and rotate it back and forth slightly until it drops flush against the intake manifold. When it does, install its retaining clamp and tighten its bolt securely.

Sensors

If you tagged all your sensors before you removed them, you'll know



As the distributor drops into the engine, the rotor will move clockwise. If the rotor was positioned about 30deg before the mark for cylinder #1, it should be roughly aligned with the mark when the distributor is fully seated.

exactly where to install them now. If you didn't tag them, you're in trouble.

If you didn't tag the sensors, try to determine their location by screwing them into the manifold where you think they belong. The thread diameter and pitch of the sensor can help you, because they frequently allow you to install only one particular type of sensor.

When you're pretty sure where each sensor goes, apply a thin coating of automotive pipe thread sealer to the bottom of their threads and screw them into the manifold. Avoid getting any sealer on the sensing end of the sensor, as it may affect the sensor's reading. While making sure you're not bending the electrical tangs on the sensors, tighten them securely.

Thermostat

When installing the thermostat, remember that its pointed end must point away from the engine for proper operation. Also keep in mind that in

many applications, the studs used to retain the thermostat housing are links to the engine for the ECM grounds. Consequently, it's very important that these studs be free of corrosion and securely installed to avoid intermittent driveability problems.

With that in mind, install the housing by slipping the studs or bolts through its mounting holes, then placing the gasket over the threads of the fasteners. Position the housing to the manifold, then tighten the fasteners to 17lb-ft torque.

Connecting the Engine Hoist

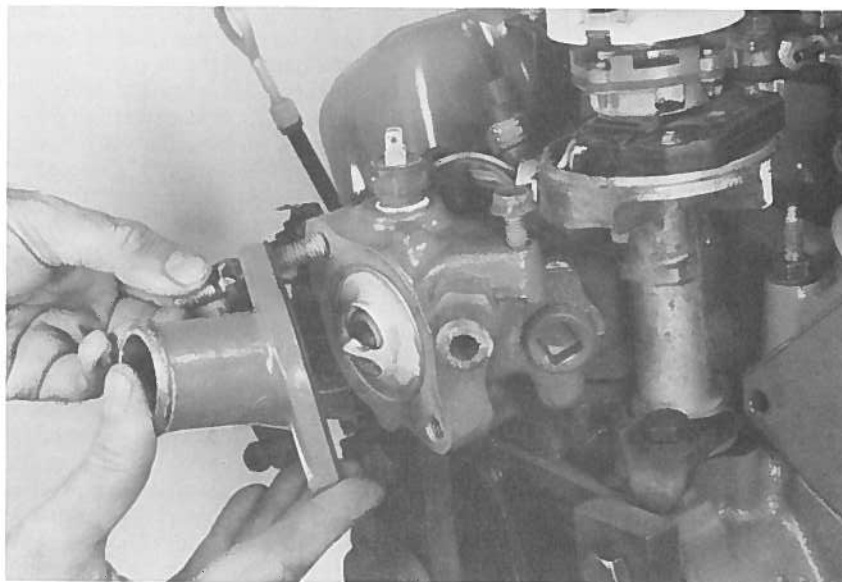
At this point, only installation of the camshaft plug and flywheel (or flexplate) and clutch assembly remain. To install them, however, you'll need to remove the engine from the stand. So, begin this operation by connecting the lift chain to the engine, using the factory eyelets or sturdy bolts fitted to the ends of the cylinder heads. Remember that you'll need to make a loop in the chain for the hoist to grab. But to do this you need to consider where to place the loop.

For rear-wheel-drive vehicles, the loop should be positioned closer to the front of the engine, as this will make it easier to get the engine into the engine compartment and mated with the bell housing. For front-wheel-drive vehicles, position the loop just forward of the center of the engine. This allows you to get the engine between the frame side rail and bell housing.

With this in mind, make the loop in the chain by running a large-diameter bolt through two links on the chain and securing it with a nut. Use heavy washers under the head of the bolt and nut to prevent the bolt from slipping through the links. Then position the chain into the hook on the end of the hoist. Make sure the hook is between two links to prevent the chain from slipping. While standing clear of the engine, lift it up just far enough to take the pressure off the engine stand. Then remove the stand head from the back of the block.

Camshaft Plug

With the back of the block accessible, install the camshaft plug. Take a new plug gasket and align its bolt holes with those in the block. If they won't line up, flip the gasket over and try again. The gasket only fits on the block one way. Then position the plug over the gasket.

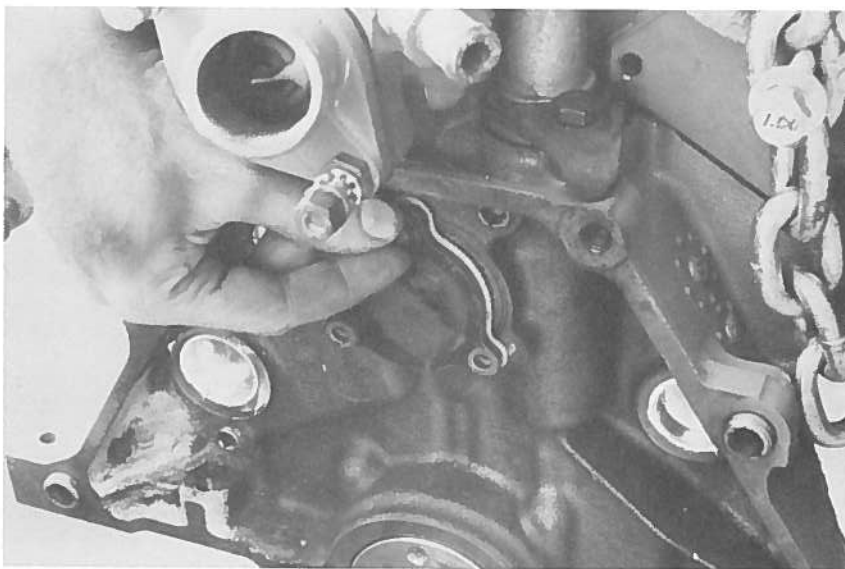


The pointed end of the thermostat must face the thermostat housing for proper operation.

Since retention of the plug bolts is critical to prevent oil from leaking from the plug (which requires separation of the engine and transmission to fix), clean the plug retaining bolts and their holes in the block with brake cleaner. When the brake cleaner has dried, apply one drop of Loctite Threadlocker 242 to the threads of the bolts and those in the block. Then screw the bolts into the block and tighten them to 84-96in-lb torque.

Flywheel and Flexplate

Finish your work at the back of the block by installing the flywheel or flexplate. Just as with the camshaft plug retaining bolts, flywheel bolt retention is critical, so clean the threads of the flywheel bolts and the threads in the crankshaft flange with brake cleaner. After the threads have dried, apply two drops of Threadlocker 242 to the bolt threads and those in the crankshaft flange.



Remember to install the camshaft plug while the rear of the block is still acces-

sible. The gasket and plug fit only one way.



After cleaning the threads on the bolts and in the crankshaft flange with brake cleaner, apply a couple of drops of Threadlocker 242 to all the bolts and threaded holes to prevent the flywheel bolts from loosening. Note that the bolt holes in the flexplate are aligned with those in the crank.

Now look closely at the bolt holes in the flywheel. You'll notice that three of the bolt holes are closer together than the others. That's because the center "bolt hole" in the closely positioned three isn't really a bolt hole at all. It's just a hole, and it must align with the unthreaded hole in the crankshaft flange when the flywheel is mounted to the back of the crank.

If you're installing a flexplate for an automatic transmission, make

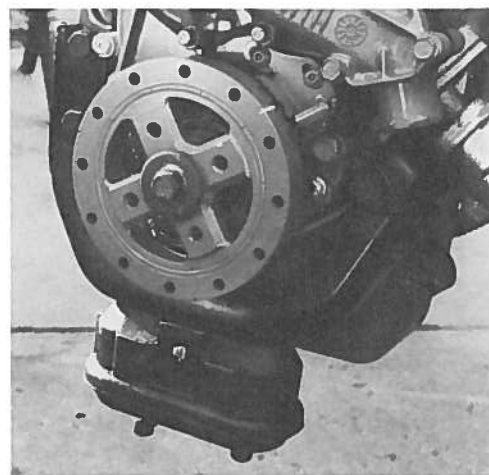
sure the flexplate is positioned so that the teeth on the ring gear are away from the block. If the flexplate is resting on the block when the bolts are tightened, it's on backwards. When the flywheel (or flexplate) is properly aligned to the crankshaft flange, slide the serrated washers over the flywheel bolts and screw the bolts in the crank.

To torque the bolts to specifications, you'll need to keep the flywheel (or flexplate) from turning. Although there are a number of ways to do this, here's a simple way: Screw a bolt into the bell housing flange on the back of the block. Then have an assistant use it as a fulcrum while they engage the tip of a large screwdriver or pry bar between two of the ring gear teeth. Have your assistant push inward against the teeth while you torque the bolts to specifications, working in a star pattern to equalize the torque.

Also ask your assistant to hold the flexplate (or flywheel) for a few minutes more while you finish the installation of the damper and crankshaft pulley bolts. Do this by applying two or three drops of Loctite 242 to the threads of these bolts. Then torque them to specifications, starting with the damper bolt.

Clutch Disc and Pressure Plate

For those of you with manual transmissions, now's the time to install the clutch disc and pressure plate. Place the disc against the fly-



If the engine is going into a front-wheel-drive vehicle, install the front motor mount and bracket to the engine now. Note that the timing mark on the damper is at top dead center on the compression stroke for cylinder #1.

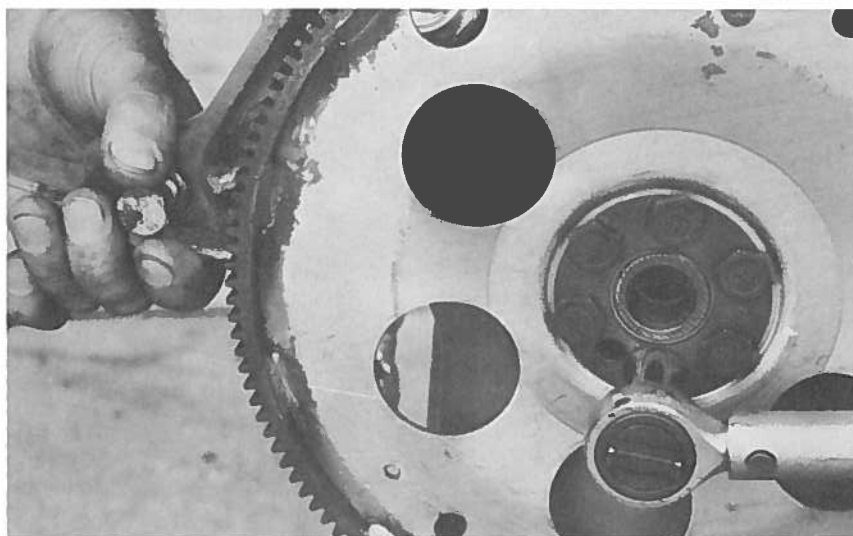
wheel so that the springs in the hub are closer to the transmission when installed on the input shaft. Then position the pressure plate over the disc and loosely install the retaining bolts. If you're reusing your pressure plate, make sure the alignment mark you made during removal is aligned with the mark on the flywheel so you don't have an engine imbalance problem.

Now slide a clutch piloting tool through the splines in the disc into the crankshaft pilot bushing. This is important as it allows you to mate the engine to the input shaft on the transmission. When the disc is aligned, tighten each pressure plate bolt a little at a time to prevent damaging the pressure plate. When they're all fully seated, torque them to specifications.

Front Motor Mount and Bracket

If the engine is going into a front-wheel-drive car, install the front motor mount and bracket to the front of the block. This operation will be a lot more difficult if you wait until the engine is in the engine compartment. However, put the bolts in only half-way, as this allows you to adjust the position of the motor mount during engine installation. You'll need to do this to align the motor mount studs to the holes in the frame.

Rear-wheel-drive engines should have their motor mounts fitted now as well. Tighten the bolts securely.



You'll need an assistant to keep the flexplate (or flywheel) from turning as you're torquing the bolts.